ARAFURA
RESOURCES LIMITED

Environmental Impact Statement

NOLANS PROJECT
ARAFURA RESOURCES LTD

MAY 2016

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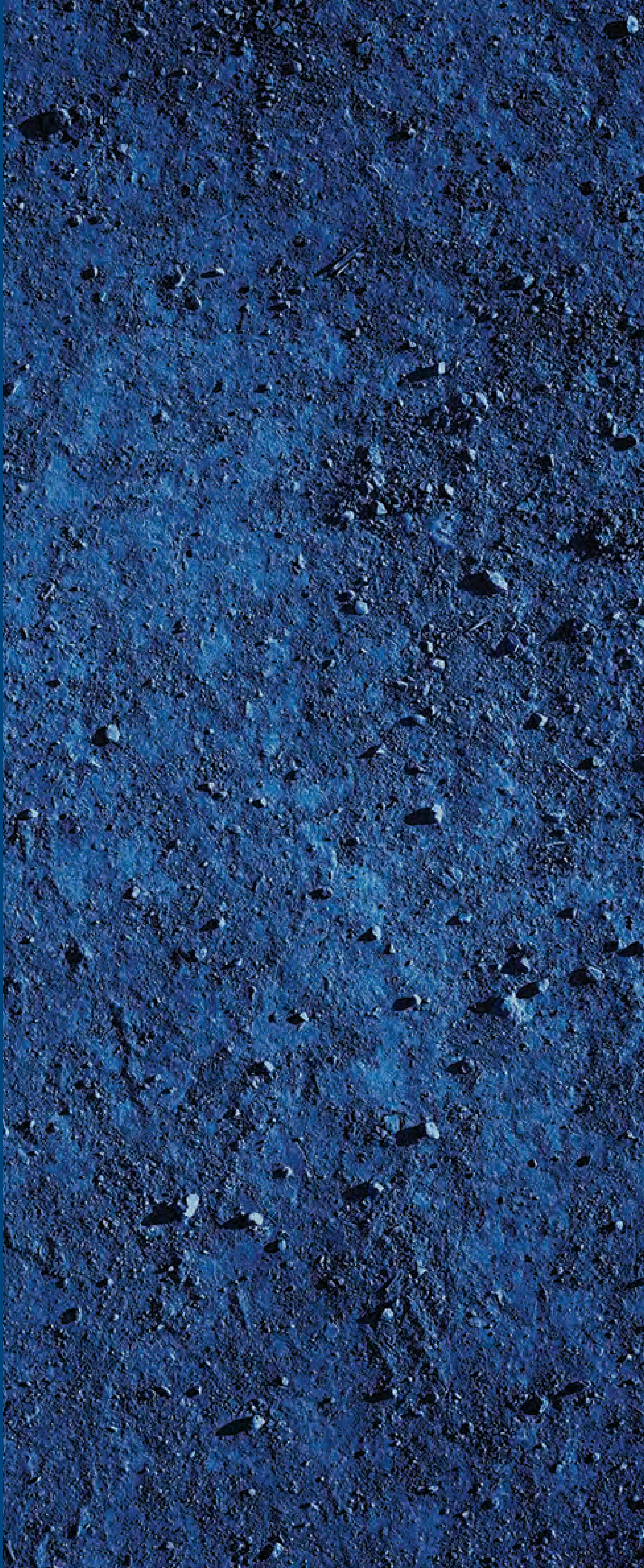

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ARAFURA RESOURCES LIMITED

GHD

volume one

EIS report – Chapters 1 to 18

Executive summary

Executive summary

Introduction

Arafura Resources Limited (Arafura) is proposing to develop the Nolans Project (the project) located approximately 135 kilometres (km) north-northwest of Alice Springs, Northern Territory (NT).

The project is targeting a mineral deposit hosted in fluorapatite and containing rare earths. The demand for high quality rare earth products in key growth areas such as the automotive, clean energy and electronics sectors, is forecast to grow at five per cent per annum over next ten years, driven by technology innovation, particularly in the industrial and clean energy sectors. The project has the potential to supply 10 per cent of the world's magnet feed demand through its production of NdPr (neodymium-praseodymium) oxide.

The Nolans Project is 100 per cent-owned by Arafura, an Australian stock exchange listed company and an emerging rare earth producer. The project will be the company's first mining and chemical processing operation. Project planning and feasibility has progressed over a number of years as Arafura's knowledge and understanding of the mineral deposit, processing technologies, project economics, markets and site conditions has developed through its extensive exploration, metallurgical research and engineering development programs.

Since 2007, a range of project locations, processing configurations and project inputs have been considered and investigated including:

- An open cut mining operation and concentrator
- Producing mineral concentrate to be transported via a dedicated haul road
- From the mine site to the Adelaide-Darwin railway line for loading and rail transport to Darwin; and then either:
  - Development of a processing facility, including a separation plant, at Wickham Point in Darwin Harbour, or
  - Export of mineral concentrate to China for downstream processing, or
  - Loading and rail transport to Whyalla in South Australia, and development of a processing facility including a separation plant on land owned by Arrium Steel.

In the earlier stages of project planning, hydrological investigations to identify a sustainable water supply for the project focused on groundwater from the Ti Tree Water Control District north east of the Nolans mine site. However, in 2012, Arafura shifted its attention towards the northern Burt and eastern Whitcherry basins (herein referred to as the Southern Basins) southwest of the mine site. The Southern Basins area provides a sizeable, high-yielding, slightly brackish groundwater system that has the capacity to service a reconfigured project with all project infrastructure in Central Australia.

After further investigation, this configuration was modified to remove the downstream rare earth separation plant to an offshore location where the required large quantities of hydrochloric acid and caustic soda would be more readily available. This decision also removed the requirement to transport very large volumes of liquid reagents to the Nolans site from Darwin Port.

The decision to relocate and consolidate the processing plant back to the Nolans site in Central Australia has a number of short and long-term economic benefits for the region, and other logistical and environmental benefits including:

- Elimination of the transport of large quantities of radioactive mineral concentrate via road and rail through a number of communities
- Containment of all radioactive elements to the Nolans site
- Increased opportunities for local infrastructure development.

The project is in the Definitive Feasibility Study phase and Arafura is seeking environmental approval for the project.

Environmental assessment process

In December 2014 Arafura lodged a variation notification to the NT Environment Protection Authority (NT EPA) in accordance with the Section 14A ‘Procedure where proposed action altered’ under the NT *Environmental Assessment Act 1982* (EA Act).

Pursuant to Section 14A of the Environmental Assessment Administrative Procedures, the NT EPA considered the alteration and determined that an Environmental Impact Statement (EIS) is necessary to assess the project.

In February 2015, the Proponent also submitted a referral (EPBC 2015/7436) to the Federal Minister for the Environment. In March 2015, the delegate of the Minister determined the project to be a controlled action, and that assessment and approval is required at a federal level. Triggers for assessment under Commonwealth legislation include the potential to have a significant impact on the following matters of national environmental significance that are protected under Part 3 of the *Environment Protection Biodiversity Conservation Act 1999* (EPBC Act):

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

The project is being assessed under a bilateral agreement between the Australian and NT governments made under section 45 of the EPBC Act. Arafura is seeking approval under the EPBC Act and EA Act.

Project description

The Nolans Project comprises the mine site, a processing site, a borefield area and accommodation village site, and interconnecting access roads and utility service corridors. Key project components are summarised in the following table.

Key project components

Element	Characteristics
Project Life	
Construction period	2 years
Operational period	41 years
Production Estimates	
Ore mined	54.3 million tons (Mt) life of mine (LOM)
Waste mined	304 Mt LOM
Plant feed	Average 900,000 tonnes per annum
Production	Average 20,000 tonnes per annum total rare earth oxide (TREO)
Mine site	
Pit	An open pit will be excavated to a depth of 225 metres with a surface area of up to 135 hectares
Materials handling	Conventional open pit methods (drill, blast, load and haul) at a maximum overall mining rate of 10 Mt per annum ore and waste
Waste	Six waste rock dumps (WRDs) will receive a LOM waste quantity of 158 million loose cubic metres constructed to a height of about 50 metres in 10 metre lifts interspersed with 5 metre wide berms
Topsoil storage areas	Topsoil storage with a footprint of 95 hectares and height of about three metres
Tailings Storage Facility	Flotation tailings storage facility (TSF) comprising LOM envelope of 245 hectares and an embankment height of around 25 metres to store 45 Mt)
ROM Pad	(ROM pad to provide a facility for selective mining and ore blending (up to three months' ore supply)
Long-Term Stockpile	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
Comminution and beneficiation	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
Slurry transfer pipeline	A single pumping stage slurry pipeline between the concentrator and processing plant transports mineral concentrate to the processing plant at the processing site
Processing site	
Extraction processing units	Sulfuric acid pre-leach process produces a solid feed, containing the majority of the rare earths (REs), for the sulfation (acid bake) process Sulfation process liberates the REs for subsequent processing and extraction Water leach is used to recover REs and sodium sulfate added to water leach liquor precipitates the REs for further filtering and washing

Element	Characteristics
	Double sulfate precipitation salt is converted to RE hydroxide and then mixed with dilute hydrochloric acid and crystallized to produce RE chloride and cerium carbonate products The RE chloride intermediate and cerium carbonate products will leave the facility in bulk bags stored in standard shipping containers for transport to Alice Springs by road and then by rail to the Port of Darwin for export
Sulfuric Acid Plant	The processing plant demand for sulfuric acid will be serviced by an on-site sulfur burning plant
Process residue storage facilities (RSFs)	To store phosphate, impurity removal and water leach residues in cells, with a combined potential footprint area of 160 hectares and embankment height of up to 24 metres
Evaporation Ponds	Evaporation ponds comprising six 10-hectare cells and an embankment height of 2.5 metres Sodium sulphate will be recovered for re-use in the processing plant
Power	Power demand will be serviced by cogeneration from a sulfuric acid plant (six megawatt (MW)) and gas fired on-site generation of 18.5 MW located at the processing site
Other infrastructure and facilities	
Borefield	Groundwater will be supplied from multiple bores and borefields and pumped to a centrally located transfer water pond for onward pumping to a reverse osmosis (RO) plant for use in the processing plant Overall site raw water demand is projected to be 4,777 megalitres per annum (ML/y). This comprises 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
Gas offtake pipeline	Gas supply offtake pipeline (to connect to the existing Amadeus Basin to Darwin high pressure gas pipeline)
Raw materials and reagents	Detailed logistics modelling indicates that the project will have annual movements of approximately 190,000 tonnes of in-bound raw materials, including sulfur and sulfuric acid, caustic soda and hydrochloric acid, carbonate material and fuel supplies The delivery of reagents and materials to the project will be managed from Alice Springs by an existing logistics operator Once operational the processing plant demand for sulfuric acid will be serviced by an on-site sulfur burning acid plant
Wastewater	Wastewater from the accommodation village and non-process wastewater from the processing site and the mine site will be pumped to a common sewerage treatment plant. The sewerage treatment plant will be a package type unit providing the appropriate level of treatment
Workforce	
Construction	Peak of 500 housed in a purpose built camp
Operations	Peak of 300 housed in an accommodation village

Community context

Traditional owners of the land on which Arafura will operate are Anmatjere people, with senior traditional owners living in the Alyuen, Ti Tree, Pmara Jutunta and Laramba communities and further afield in places such as Alice Springs. Aileron Pastoral Holdings Pty Ltd also hold background land tenure to the mine site, processing site, accommodation village and part of the borefield area under Aileron Perpetual Pastoral Lease (PPL 1097). The borefield also extends onto part of Napperby Station (PPL 1178). The predominant land use is cattle grazing.

The town of Alice Springs (population of about 26,000), south-southeast of the Nolans site along the Stuart Highway, is served by modern road, rail and telecommunications infrastructure. Small communities and family outstations in the surrounding area include:

- Aileron Roadhouse
- Aileron Station homestead
- Alyuen (Aileron) family outstation
- Alkuptija (Gillans Bore) family outstation
- Burt Creek (Rice's Camp) family outstation
- Injulkama (Amburla) family outstation
- Laramba community
- Napperby Station homestead
- Pine Hill Station homestead
- Pine Hill (Anyumgyumba) family outstation
- Pmara Jutunta (Six Mile) community
- Ti Tree community.

Consultation activities undertaken between 2007 and 2015 by, or on behalf of, Arafura are described in the EIS. The information and feedback collated during the consultation process contributed to the social impact assessment and management planning process.

Arafura will continue to communicate elements of the project, using strategies tailored to suit various audiences. Ongoing community consultation and engagement will aim to continue building relationships, and provide stakeholder groups with opportunities to input into project considerations.

Risk assessment framework

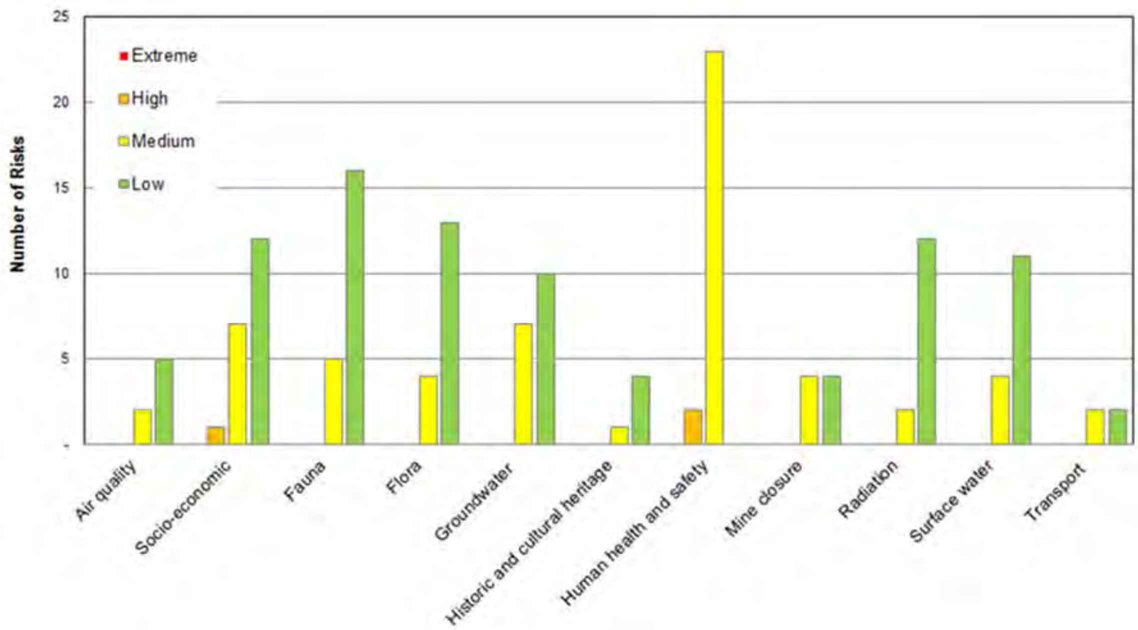
The EIS has been undertaken with a specific emphasis on the identification, analysis and mitigation of potential environmental risks. The risk assessment approach provides a framework for identifying components of the project with the potential for greater environmental risk and highlights project specific control measures to minimise or mitigate the likelihood and consequence of these identified risks.

The impact pathways and proposed controls have been used to inform the environmental management framework for the project, including an Environmental Management Plan and associated sub plans.

A risk register was established to document the findings of the risk assessment process, presented separately for environmental and socio-economic risks. The risk register contains details of impact pathways, consequences, planned controls inherent in the project description, an initial risk assessment, additional controls, and the residual risk rating.

The environmental risk assessment identified 81 risk events, of which several had potential impacts on multiple environmental receptors. As a result, 135 impact pathways were identified and assessed through the environmental risk assessment process. The social risk assessment identified and assessed 22 socio-economic risk events, of which 18 were potential negative impacts and four were potential positive impacts.

The risk profile across the study area is presented in the figure below, and highlights the distribution of project risks per environmental aspect.



Distribution of residual risk ratings by study area

Key findings of the risk assessment process included:

- The majority of risks are unlikely or may occur only in exceptional circumstances
- The maximum credible consequence of most risks is no greater than a minor impact
- There were no risks identified and assessed with an Extreme risk rating, and
- There are a range of Medium level risks which will be actively managed through identified control measures.

Results of the environmental impact assessment

An assessment of the potential impacts of the proposal on the environment was undertaken in accordance with the requirements of the NT EPA and the Terms of Reference for the project. Throughout this document, the term environment includes the natural, cultural, physical and social parts of the environment.

Water

The Nolans mine site is located at the head of the Kerosene Camp Creek valley on the north facing slopes of a northeast – southwest trending ridge of the Yalyirimbi Range, whilst the processing site is situated on the southern slopes of the same range. Topographic elevation is 886 metres above sea level (m ASL) at Mt Boothby to the east of the mine site, and 1,006 m ASL at Mt Freeling to the west. Most of the Kerosene Camp Creek valley floor at the mine site is typically between 650 and 700 m ASL whilst the processing site is at an elevation of about 670 m ASL.

Semi-arid regions such as the area in which the mine is located are typically characterised by conditions in which evaporation closely matches rainfall and virtually all rainfall evaporates during events resulting in almost no surface runoff. This general situation will alter if intense rainfall occurs. Therefore, the occurrence of surface runoff and flows within local creeks is likely to be infrequent and only occur during exceptional rainfall events, which may occur only once or twice each year.

Ephemeral surface water flows originate in the catchments of the Reynolds Range and Yalyirimbi Range. These flows typically result in terminal creeks (i.e. their flow does not make it to a secondary water feature), including Gidyea Creek, Day Creek, Wallaby Creek, Wicksteed Creek, Kerosene Camp Creek, Rabbit Creek and Allungra Creek. Napperby Creek is the exception in that it discharges to the ephemeral Lake Lewis, following periodic high rainfall events. Likewise, the Woodforde River also discharges to the Hanson River downstream (north) of the mine site.

The Nolans mine site is in the headwaters of the Woodforde River surface water drainage system. Kerosene Camp Creek is an ephemeral creek that flows through the centre of the mine site before joining the Woodforde River 10 kilometres to the north. Nolans Creek is a major tributary of Kerosene Camp Creek that flows adjacent to the eastern boundary of the mine site. The Woodforde River passes through the western margins of the Ti Tree (groundwater) Basin which is about 20 kilometres downstream of the mine site. The groundwater aquifer at this location along the Woodforde River is about 60 metres below ground level, down gradient of the mine site.

At the mine site location, groundwater is approximately 15 metres below the ground surface. The local aquifer at the mine site is surrounded by much lower permeability basement rocks that restrict the flow of groundwater. This local aquifer is recharged directly from surface infiltration during infrequent rainfall events and by leakage through the overlying creek bed when Kerosene Camp Creek is flowing.

The processing site occupies a small part of the headwaters of several poorly defined creeks draining southwards into the Lake Lewis catchment. Distinct channels have not formed within these headwaters and runoff from the processing site is dispersed in minor rills. It is located on the northern margin of the Whitcherry (groundwater) Basin which is one of a series of interconnected basins termed the ‘Southern Basins’ that drain westward and toward Lake Lewis, 40 kilometres southwest of the borefield.

The Ti Tree and Southern Basins are considered to connect at the eastern margin of the Southern Basins near the Stuart Highway in an area termed the Margins. The Margins area is considered to be a subtle groundwater divide with water flowing north of the divide to the Ti Tree Basin and south of the divide to the Southern Basins. The Yalyirimbi Range ridgeline between the mine site and processing site is also the surface water divide between the Ti Tree and Southern Basins.

Groundwater from the basins is the primary source of drinking water in Ti Tree, Pmara Jutunta, Laramba, and Alyuen Community as well as at Aileron Station Homestead and Aileron Roadhouse. Groundwater is also used for domestic purposes at Napperby and Pine Hill Station Homesteads. In addition to this domestic use, groundwater is important for stock water and irrigation for agriculture in the Ti Tree Basin.

Environmental users of water (surface and groundwater) in the study area include riparian vegetation, vegetation on the floodout areas on the plains and in the hills, as well as fauna.

Potential impacts on surface water conditions

Significant areas of catchment occur upstream of the mine site boundary. During intense rainfall events, runoff that originates from upstream catchments will pass through the mine site and processing site and could therefore increase the volume of mine affected water. For example, if left undiverted, Kerosene Camp Creek will drain directly to the open pit.

The separation of clean and mine affected water, and the diversion of clean water run off around the Nolans site, will be achieved by means of flood protection bunds and shallow drainage ditches. A proposed diversion of Kerosene Camp Creek will change the direction of flow within a tributary of Kerosene Camp Creek away from the open pit, and towards the major western tributary of Kerosene Camp Creek.

Additionally, flood modelling was used to understand the extent, depth and velocity of potential flooding of the Nolans site during intense rainfall events, and the probability of the mine site experiencing flood events with an annual recurrence interval of between 10 and 1,000 years during the 43-year LOM. The positioning and design of mine infrastructure will take account of the risk of flooding along watercourses and will either position infrastructure outside the 1 in 1,000-year annual recurrence interval (ARI) flood extent, or incorporate flood protection measures into flood prone areas.

Construction of access roads and other project infrastructure has the potential to cause a reduction in the existing capacity of channels or an increase in channel bed gradient. This could lead to a localised increase in flow velocity during rainfall events, leading to the potential for erosion of creek beds. Conversely, if channel widths are increased or channel bed gradients reduced this could result in a reduction in the velocity of flow and an increased potential for the deposition of sediment.

Preliminary flood modelling of catchments upstream of proposed roads suggests that flood depths and velocities during a 1 in 1,000-year ARI event will not exceed 0.5 m and 1.0 m/s respectively. To prevent problems associated with erosion or sedimentation at road crossings, changes to the drainage path and flow conveyance capacity of creeks will be minimised. Controls to reduce overland flow-induced erosion will also be implemented in engineering design prior to construction.

Contaminated water (e.g. by contact with ore and waste rock) is a potential impact to surface and/or groundwater receptors that may arise during:

- The extraction of ore (pit dewatering)
- Ore processing at the mine site (tailings from crushing and beneficiating the ore) and processing site (residue streams).

The potential for pit water to become contaminated is considered to be low given that geochemical testing of ore and waste rock has identified low sulfur content, generally low metal toxicant content and low metal and salt leachability of the mined material. The potential for contamination of rainfall infiltrating waste rock dumps (WRDs) is also considered to be low.

The potential for the tailings storage facility (TSF) or residue storage facilities (RSFs) to discharge contaminated water, either by overflow during extreme rainfall or by seepage into the shallow alluvium of adjacent local creeks, has been considered and the risk has been assessed as being low (risk of overflow) to medium (risk of seepage to groundwater).

TSF and RSFs will have a design storage capacity that is able to contain a 1 in 100-year ARI average annual rainfall whilst retaining sufficient additional freeboard to accommodate a probable maximum precipitation (PMP) 72-hour storm rainfall event. RSFs will have low permeability liners and leakage collection systems to reduce the risk of seepage to groundwater.

Additionally, dewatering of the open pit will cause a local drawdown of groundwater levels in the area surrounding the mine pit. This will cause any seepage of surface water from WRDs and other areas of the mine site to migrate towards the pit, thereby reducing the risk of potential impact on the surface water or groundwater of areas beyond the zone of groundwater drawdown (i.e. more or less coincident with the mine site boundary).

Potential impacts on groundwater conditions

A numerical groundwater model was built to represent the groundwater system under the influence of the project’s operating conditions, and under closure conditions, i.e. a 1,000-year predictive groundwater flow model. The model was used to test the potential impact of two primary stresses associated with the project:

- The mine – i.e. sump pumping flows are outputs from the model
- The borefield – i.e. bore pumping flows are inputs to the model.

Modelled impacts to groundwater availability are considered from the perspective of groundwater flows (volumes over time), groundwater flow direction and groundwater drawdown. In addition, the modelled impacts are considered in terms of impacts to groundwater chemistry and quality.

The Southern Basins borefield is planned to be operated at approximately 13,000 m^3/day (150 L/s or 4,700 ML/year).

The predicted mine dewatering peaks at 4,000 m^3/day (46 L/s or 1,450 ML/year) and steady-state post-closure inflows at approximately 700 m^3/day (8 L/s or 250 ML/year). As basement groundwater is likely to be lost to the system via pit evaporation, there is clearly a net loss to the system in the long term. The net loss of water from storage within the Ti Tree Basin (including its basement rocks) was modelled at approximately 8 m^3/day (0.1 L/s or 3 ML/year) during mining increasing to 37 m^3/day (0.4 L/s or 13 ML/year) at the end of the 1,000-year closure modelled prediction.

No reversal of groundwater flow direction occurs anywhere within the model area during mining except for immediately adjacent to the mine pit and immediately adjacent to the borefield bores (but not across aquifers, i.e. groundwater flow in the borefield aquifer is still westwards despite the pumping). The modelled reversal of flow direction at the end of the 1,000- year closure modelled period extends within the basement rocks radially from the mine pit for approximately 4 km towards the Aileron Station Homestead and Aileron Roadhouse area.

The modelled groundwater drawdown is large in terms of magnitude adjacent to the mine but is likely to have very steep gradient due the low permeability of the surrounding country rock mass. This, combined with the removal of all surface water flow (amongst other things) is likely to have irreversible effects on riparian vegetation for a limited length (estimated at approximately 1 km) of Kerosene Camp Creek. The aquifer confined to the orebody at the Nolans mine site will be almost completely mined. Beyond this area, stock bores on Aileron and Pine Hill stations may experience minor drawdowns in the long term.

The modelled groundwater drawdown in the borefield is very large in terms of its extent. The flow rates should not be considered sustainable in the very long term (i.e. indefinitely) as it is not likely replaced by recharge at the same rate as the proposed discharge rate. The borefield is considered an appropriate use of the aquifer provided borefield abstraction ceases at the end of the assessed LOM and the aquifer allowed to recover (and subject to groundwater model calibration).

The minor current and potential future uses should not be impacted in a material manner, although it is recognised that minor drawdowns at nearby stock and drinking water sources may occur.

The chemistry of groundwater flowing towards the pit is not likely to be greatly different from the existing groundwater chemistry in the area. Once in the pit, the net evaporation will result in a hypersaline pit lake. Flow will be radially towards the pit lake and thus contribute to the concept of a zero discharge site. The likely chemistry of this pit lake has not been modelled, however, it is highly likely to be of no long-term beneficial use.

In the unlikely situation where the pit is filled and overflows either to the surface water bodies or groundwater system (i.e. the pit lake rises above adjacent groundwater levels to the point where it is no longer behaving as a sink), this contaminated water could discharge. As all storage facilities are designed as zero discharge facilities (i.e. evaporation controlled), they will be designed or managed such that they do not breach or overflow either to the surface water bodies or groundwater system.

The modelled groundwater flow regime displays almost no change (impact) at the model (regional) scale when viewed from a flow direction or groundwater head perspective. As such there is no justification for any speculation of material changes in groundwater chemistry or quality within the aquifer.

Despite this, there remains the minor potential for hypothesised impacts resulting from the proposed extraction of groundwater from the Southern Basins. These could include more groundwater with lower quality flowing from storage within the basement rocks, and fresher water associated with recharge from Day Creek being drawn eastwards, thus altering the quality of water available for drinking.

A water management plan will be implemented including measures to manage flood and stormwater related issues and monitoring of groundwater levels, water chemistry and water quality. It is proposed that the groundwater model be recalibrated following collection of data once operations and pumping commences. This will inform borefield management practices and any changes, if required, to manage and mitigate impacts.

Flora and fauna

The Nolans site is located in the Burt Plain Bioregion, which is known to contain more than 1,100 flora species and 350 fauna species. There are 16 sites of botanical significance and six sites that are listed in the directory of important wetlands, but none of these occur within or near the study area. Lake Lewis site of conservation significance is 40 km to the southwest of the borefield area.

Existing threats to flora and fauna values that have been identified within the bioregion include grazing by livestock, introduced plant species and introduced predators, and changes in fire regimes.

Separate flora and fauna surveys for the Nolans Project have been completed over the period 2006 to 2015, the most recent during April and July 2015. Survey techniques were consistent with the *Northern Territory Guidelines and Field Methodology for Vegetation Survey and Mapping*.

Findings from flora and fauna survey included the following:

- Flora species recorded within the study area and their associated vegetation communities are relatively common in the region with the exception of a few species. No threatened plants were recorded within the study area.
- A total 326 flora species, comprising 319 native species and 15 exotic species were recorded within the study area during the 2011 and 2015 survey periods.
- Eleven flora species listed as having conservation significance in the Burt Plain Bioregion were recorded within the study area. These species have conservation significance due to them being either at the limit of their range or being rare in the bioregion.
- A total 14 vegetation communities were identified within the study area. The dominant vegetation types within the study area are Mulga shrublands, which occur on alluvial fans and plains containing clayey red earths and Triodia hummock grasslands which grow on sandy plains.
- Vegetation across the study area is generally in good condition with little anthropologic disturbance and high species richness.
- Less common vegetation communities that occur in small patches or along linear drainage lines throughout the study area include mixed woodlands dominated by bean trees, and riparian vegetation. In these areas there is clear evidence of impacts associated with cattle grazing including weed invasion, reduction in ground cover species richness and soil erosion. In particular, there is a high abundance of Buffel Grass.
- A total 174 native terrestrial fauna species were recorded, including 25 mammals, 103 birds, 41 reptiles, three frogs. Five introduced fauna species (all mammals) were recorded.
- Mulga shrubland had the largest species count, influenced by large species numbers of mammals and birds in particular. Triodia (Spinifex) grassland on sandplain was also species rich, influenced by relatively high diversity of mammals and reptiles. Rocky habitats were moderately species-rich for fauna.
- Twenty-seven fauna species that do occur or could occur within the study area are listed as threatened (or as a related category of conservation concern) under the EPBC Act

and/or the *Territory Parks and Wildlife Conversation Act* (TPWC Act). These include nine species (four mammals, four birds and one reptile) that were recorded in the study area, and 18 others (six mammals, nine birds and three reptiles) that were not.

- Six of the threatened species that do occur or could occur within the study area are listed as Vulnerable or Endangered under the EPBC Act including:
  - Four mammals
  - Brush-tailed Mulgara, *Dasycercus blythi* (Vulnerable);
  - Black-footed Rock-wallaby, *Petrogale lateralis* MacDonnell Ranges race (Vulnerable);
  - Southern Marsupial Mole, *Notoryctes typhlops* (Endangered);
  - Bilby, *Macrotis lagotis* (Vulnerable).
  - One bird
  - Princess Parrot, *Polytelis alexandrae* (Vulnerable);
  - One reptile
  - Great Desert Skink, *Liopholis kintorei* (Vulnerable).
- Black-footed Rock-wallaby is known (from July 2015 targeted survey) to occur throughout the rocky habitats of the eastern parts of the Reynolds Range which incorporates the study area. Only transient populations appear to occur within the actual mine site footprint, however a viable population was found to occur in the immediate vicinity of the mine site.
- The Brush-tailed Mulgara was found to be well represented within the sandplain habitats of the borefield (with a frequency of 2.5 active Brush-tailed Mulgara burrows per hectare). It is assumed that this species would be present within sandplain habitats throughout the study area and surrounds at similar density given that the same habitat exists in a local area.
- The Great Desert Skink was recorded on only one occasion in the far south-west of the proposed borefield. Although only one active Great Desert Skink warren was recorded despite extensive searches of the proposed borefield, it is possible that this species could occur within any of the sandplain habitats of the study area.
- The Greater Bilby was not recorded during the previous surveys and there are no historic records within the proposed project footprint, however it is possible that this species could occur within any of the sandplain habitats of the study area.
- Southern Marsupial Mole was not recorded during the targeted surveys and no historical records exist for the study area, however it is a poorly known species and rarely seen/reported because of its subterranean habits. The sandplain habitat in the southern part of the study area is potentially suitable.
- The Princess Parrot was not recorded during the previous surveys and there are no historic records within the proposed project footprint, however it is possible that this species could occur within any of the habitats within the proposed project footprint apart from the rocky habitats.

Potential impacts on flora and fauna

Vegetation clearing will involve removal of a moderately diverse range of non-threatened native plants; however, none of the vegetation communities within the Nolans site are considered to have significant levels of species richness or structural complexity.

Vegetation communities present within the Nolans site are well represented in the Burt Plain Bioregion. The two most common vegetation communities in the bioregion, Mulga shrublands and mixed woodland over tussock grasses together comprise 78 per cent of the vegetation proposed to be impacted within the Nolans site.

The fauna as a whole is likely to experience no significant effects from the clearing and infrastructure development itself, with other impacts discussed below such as the introduction of exotic predators likely to be more important for future management.

The introduction of new weed species and/or spread of existing weed species into new areas as a result of project activities can result in displacement of fauna from habitats as habitat quality deteriorates, and changes in fuel load resulting in changes to fire frequency and intensity.

Buffel Grass has been identified as a present and significant threat in the Burt Plain Bioregion. Further spread of Buffel Grass has the potential to displace native flora and increase fire severity due to its ability to accumulate higher amounts of combustible biomass compared to native understory species.

Additionally, the introduction of new fauna species and/or spread of existing exotic fauna species into new areas as a result of project activities can result in:

- Increased predation pressure by opening up of new areas to feral predators such as cats or red foxes
- Increased competition by natural areas becoming invaded by aggressive and dominating native and pest species
- Large-scale decline in habitat quality as natural areas are trampled and grazed by non-native species/domestic stock.

The most serious risk to Black-footed Rock-wallaby species is likely to come from unplanned wildfire and exotic flora/fauna. Both have the potential if unmitigated to exert a High risk on population size, critical habitat and breeding cycles, and lead to population decline and inhibit species recovery. However, the implementation of mitigation and management measures will remain Low to Medium.

The most serious risk to the Great Desert Skink and Brush-tailed Mulgara is likely to come from unplanned wildfire and exotic flora/fauna. Both have the potential if unmitigated to exert a High risk on population size, critical habitat and breeding cycles, and lead to population decline and inhibit species recovery. The implementation of mitigation and management measures will reduce these impacts to a point where the residual risk will remain Low to Medium.

There is potential for the project to lead to increased wildfire in the study area in the event that appropriate mitigation measures are not implemented. It is expected that all of the threatened species either known or potentially occurring within the study area would be affected by fire (both positive and negative impacts).

Controlled and strategic cool patch burns of spinifex sandplain habitat could have positive outcomes for species such as Greater Bilby (promotes food plants). Extensive burns (not patchy) of Great Desert Skink and Black-footed Rock-wallaby habitat could be detrimental as the fire would remove important shelter and food resources. Extensive frequent fire may reduce ground-layer vegetation cover which could increase the chance of predation by cats/foxes.

Too frequent, hot and extensive wildfire is unlikely to benefit fauna in the study area and surrounds, whereas localised cool patch burns are likely to be beneficial. The residual risk of wildfire impacting fauna has been assessed as Medium.

Groundwater dependent vegetation in discharge zones and floodout areas would be susceptible to rapid changes in groundwater levels, in particular riparian woodlands, which are likely to be at least partially dependant on groundwater.

The extent of the impact to riparian vegetation, and on fauna species relying on riparian habitat, will be greatest immediately adjacent to the pit and decrease radially with distance from the pit. A reasonable estimate for the down gradient extent of this has been made, based on both the modelled drawdown cone and the point where Kerosene Camp Creek receives additional surface water flow from adjacent catchments (which is likely to in part mask this impact) at the confluence with Nolans Creek. The length of Kerosene Camp Creek beyond the mining area that may be incapable of maintaining the current riparian vegetation is anticipated to be approximately one kilometre.

Vegetation communities that are at least partially dependent on surface water flows (i.e. Mulga shrubland in flood out areas and the riparian vegetation along Kerosene Camp Creek) will also be potentially impacted by alterations in surface or sub surface flow associated with the construction of project infrastructure including roads and areas of hardstand. Changes in flow may include changes to areas of natural inundation, increased concentration of flows and/or disruption to sheet flow patterns.

Minimising impacts on all these species and their habitats will serve to mitigate impacts on most if not all other threatened and near threatened (i.e. as listed under the TPWC Act) species. Impacts will be controlled through planned actions that are documented in a biodiversity management plan for the project, including weed and fire management controls.

Human health and safety

Potential impacts to human health and safety associated with all stages and components of the Nolans Project addresses risks to the workforce and the general public for the duration of the project, including post-closure.

A total of 25 hazards were identified that could result in a risk to the workforce or the general public. The only hazard identified and assessed to have the potential to impact on surrounding land users was associated with off-site transport activities. All other hazards were considered to be confined to within the Nolans site footprint.

Risks identified for human health and safety included:

- Transport related risks, particularly vehicle movements and the management of traffic on and off-site
- Ground control risks, or the risk of ground failure or rock fall events
- Hazardous material exposure and the potential for personnel to be exposed to hazardous materials, particularly associated with the processing facilities

- Fire risks associated with the presence of flammable and combustible materials, and the potential for fire and explosion events
- Climate extremes associated with the location of the Nolans site in an area with high ambient air temperatures, therefore personnel may be exposed to adverse effects as a result of climatic extremes
- Remote area risks and the likelihood that personnel may be exposed to increased risks due to the remote location of the site and / or undertaking lone and isolated work in terms of increased time for emergency response, potential communication failures, black spots and long travel distances.

The two highest risks identified for human health and safety were transport-related risks including:

- Vehicle incidents associated with the off-site transport of materials and personnel on public roads, including vehicle-to-vehicle impact, single vehicle incidents (rollover, vehicle over the edge, vehicle impact with structure) and vehicle-to-pedestrian impacts
- On site mobile equipment incidents including vehicle-to-vehicle impact, single vehicle incidents (rollover, vehicle over the edge, vehicle impact with structure) and vehicle-to-pedestrian impacts.

Controls have been identified and are outlined in the EIS including engineering and operational controls, and general administrative controls. Even with controls in place however, all but two of the human health and safety hazards were assessed as having a Medium residual risk level, with the two remaining hazards assessed as High. This is due to the focus of hazard identification being on the higher consequence events to enable early identification of these events, and therefore greater ability to mitigate or use design controls to remove them from the operation.

Radiation

Radiation studies present the radiological environment of the Nolans Project including a summary of the natural levels of background radiation in the region and potential impacts from operating the project on workers, the public and the environment.

Baseline radiological studies of the Nolans site and of the region, including environmental and occupational radiation sampling and monitoring, have been carried out since 2005. The key findings from these studies are as follows:

- The project area is radiologically identified by the extensive near-surface Nolans Bore deposit
- The broader region is characterised by a large number of areas with higher concentrations of uranium and thorium compared to the Australian continent average
- There is elevated radon and thoron in the region due to rock outcrops containing elevated concentrations of uranium and thorium
- Radon and thoron concentrations in the air are elevated near the deposit and vary by up to two to three orders of magnitude
- The deposit has a radiological signature for thoron, radon and gamma radiation

- There is natural variation in radon and radon decay product concentrations throughout the day
- The thoron concentrations in the region are significant; however, the thoron decay product concentrations are low.

Radiation doses to workers and to members of the public are regulated in all Australian States and Territories under the relevant state Radiation Safety, Control or Protection Acts and associated Regulations. These Acts and Regulations in general conform with the codes and guidelines issued by the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) and international agencies.

The basis of radiation protection is dose limitation. The recognised limit for radiation doses to workers arising from work or industrial activities is 20 millisieverts per year (mSv/y), averaged over five years, with a maximum of 50 mSv in any one year. For members of the public, the limit is 1.0 mSv/y.

Assessment of worst case for the Nolans Project included:

- For occupational dose, estimates for mining and processing plant personnel, assuming full time exposure (2,000 hours per year)
- For member of the public dose, estimates have included
  - The accommodation village, located approximately five kilometres from the processing plant and nine kilometres from the mine site (two exposure scenarios have been modelled – fulltime occupation (8,760 h/y) and part-time occupation (4,000 h/y) of the village
  - Aileron (includes Aileron Roadhouse, campground and houses, and the Aileron Station Homestead and workers' accommodation), located approximately 12 kilometres from the processing plant and 13 kilometres from the mine site
  - Alyuen Community, located approximately 12 kilometres from the processing plant and 15 kilometres from the mine site.

The assessments are based on the results of air quality modelling which provides estimates of radiation levels in the wider environment resulting from airborne emissions from the project area.

The potential impacts to workers, the public and the environment are summarised below.

Radiation exposure to workers (occupational dose)

For gamma dose rates the in-pit gamma dose rates would be low because the level of contained thorium is low. There would be limited gamma from process material in the concentrator. There would be more significant gamma from higher specific activity thorium hydroxide waste residue in key sections of the processing plant.

Doses from exposure to radon decay product and thoron decay product is expected to be low in the mine but higher for process plant operators where isotopes of thorium and radium may accumulate in parts of the processing plant.

Doses from inhalation of long-lived radionuclides in airborne dust would be low.

A summary of the predicted doses is provided in the table below.

Summary of worker dose estimates

Worker category	Radiation dose (mSv/y)			
	Gamma	Dust	RnDP/TnDP	Total
Mine on-foot	1.0	0.3	0.2	1.5
Mine heavy equipment operator	1.0	0.3	0.2	1.5
Processing plant operator	1.0	0.3	1.5	2.8

Radiation exposure to the public (public dose)

Gamma radiation exposure to members of the public from sources within the project area is considered to be negligible (<0.001 mSv/y) due to the distance between the sources and the public. The sources of gamma radiation (e.g. ore stockpiles) are well within the project boundary and inaccessible by the public.

Doses from inhalation of both dust and decay products of radon and thoron are based on the estimated annual average concentrations at each of the locations of interest and are presented in the Table below. Potential annual dose from the ingestion exposure pathway has been modelled conservatively based on the assumption that all food consumed over the year is from the project site and this provides a maximum ingestion dose that could be received as a result of operations. The assessment method assumes that dust emissions from the mining operation in the surrounding environment are taken up by plants and animals, and exposure to people occurs when the plants and animals are consumed. The assessment is presented in the Table below. As noted, the gamma dose is negligible (<0.001 mSv/y) and is therefore not included in the table below.

Public total dose estimates summary

Location	Exposure Pathway Dose (mSv/y)1					
	Dust (U)	Dust (Th)	RnDP	TnDP	Ingestion	Total Dose
Accommodation village	0.000	0.006	0.001 (0.001)	0.011 (0.026)	0.032	0.050 (0.065)
Aileron	0.000	0.002	0.000 (0.001)	0.003 (0.008)	0.011	0.016 (0.025)
Alyuen Community	0.000	0.002	0.001 (0.001)	0.003 (0.007)	0.011	0.017 (0.021)

Note 1: As noted, the gamma dose is negligible (<0.001mSv/y).

Radiation exposure to flora and fauna

For the assessment of radiological impacts to flora and fauna, a worst case location of interest has been selected, which is the accommodation village. The assessment uses changes in the radionuclide concentration of soil and water, modelled via dust deposition results, to determine the level of risk.

The assessment shows that after 42 years of dust deposition, the screening level is not exceeded for any of the 15 reference species, and that the project would result in negligible or very minor radiological impacts to non-human biota and the environment.

The project design and proposed operation will be reviewed to determine likely radiation sources and levels, and options for control will be identified for these sources. Options will be chosen on the basis of effectiveness, robustness and simplicity, and following the hierarchy of controls as far as possible, with substitution and engineering prioritised before administration and personal protective equipment. A radiation management and monitoring plan will aim to keep doses a low as reasonably achievable.

Air quality

Ambient conditions (without mining) at the Nolans Project are described below.

Temperatures follow the expected seasonal pattern of warmer temperatures in the summer and cooler temperatures in the winter. Rainfall follows a seasonal trend of a wet season in the summer, and dry conditions for the rest of the year. The Spring months appear to be especially dry, suggesting this as the most vulnerable period for poor dust conditions.

The prevailing wind direction is from the south-east with an average wind speed of 2.77 m/s, remaining fairly constant throughout the year. This suggests sensitive receptors west and north-west of the site would be the most vulnerable.

Sensitive receptors comprise communities and family outstations in the surrounding area. There is a significant distance from a nominal point of the mine site, and only two of the identified receptors (Pine Hill Homestead and Annas Reservoir) are downwind of the mine site within the prevailing wind direction. The identified receptors include:

- Pine Hill Homestead – 29 km
- Annas Reservoir – 10 km
- Accommodation Camp – 9.4 km
- Aileron Roadhouse and Homestead – 13 km
- Alyuen – 15 km
- Laramba – 50 km
- Napperby Homestead – 51 km.

Assessment criteria for dust emissions resulting from the project are from various jurisdictions around Australia and are considered ‘industry standard’ for the assessment of particulate matter impact.

The pollutants of interest and associated assessment criteria (for dust emissions) are listed in the table below.

Pollutants of interest and assessment criteria (for dusts)

Pollutant	Averaging period	Criterion
Total Suspended Particles (TSP)	Annual	90 µg/m^3
Dust Particulates as PM_{10}	24-hours	60 µg/m^3 (for area sources)
Dust Particulates as PM_{10}	1-hour	80 µg/m^3 (for point sources)
Dust deposition	Annual	2.0 g/m^2/month (increment) 4.0 g/m^2/month (maximum)

Dust deposition gauges measured dust levels on site between 2010 and 2015. Daily averages of PM_{10} were generally less than 20 µg/m^3, except in summer when drier and hotter conditions associated with a period of little or no rain occurs when levels increased and appeared to stabilise between 30 and 35 µg/m^3.

Modelling was done to understand the potential dust emissions from mining operations. Control techniques have been assumed and modelled for each of the identified sources of dust at each stage of mining operations. Some processes have no controls, while other dust sources can be reduced through the application of various measures, including full enclosure if required. A maximum 74 per cent reduction in emissions from production activities was found to be achievable with the application of the control measures. Impact contours can be directly compared to the assessment criteria for dusts.

Potential impacts on air quality

The PM_{10} impact area (i.e. the area in which the criterion is exceeded) extends beyond the mine boundary to the north for 2-4 kilometres. This impact area is considered a near-mine area, and contains no human-related sensitive receptor locations. All other criterion isolines in other directions are generally contained within the mine boundary. Sensitive receptor locations such as the accommodation village, Aileron Roadhouse, Alyuen and (potentially) Annas Reservoir are well outside the assessment criterion contour.

For annual average TSP, all of the pit stage scenarios modelled generally show an impacted area contained within the mine boundary. Pit stages 2 and 4 have marginal extensions of the assessment criterion beyond the northern boundary. No sensitive receptor location would be adversely impacted.

Annualised dust deposition impact contours show that during mining stages 5 and 7, the impacted area goes just beyond the mine boundary to the north. Once again, all of these are across near-mine areas that are devoid of sensitive receptors.

The modelling therefore indicates that human health impact from mining dust is within acceptable levels. As dust has the greatest potential risk pathway to the air quality values surrounding the mining operations, an audit check on the modelled assessment will be done as part of ongoing dust monitoring during operations.

Potential gaseous emissions sources were also considered in this assessment. The sulfuric acid plant has been assessed for SO_2 emissions including ground level concentrations, and the power plant has been assessed for CO and NO_2 as a gas fired power plant.

Impacts identified are within two to four kilometres to the south-west and south of the plant, while the annual average concentration reflects the prevailing annual wind pattern, with maximum impacts to the north-west. At the nearest sensitive receptor location of the accommodation village the assessed impacts are well within the relevant criteria (SO_2) or an order of magnitude below the respective criteria (CO and NO_2).

The stack height of the sulfuric acid plant will be optimised in the design so that the relevant criterion will not be exceeded.

Noise

Noise monitoring was conducted in the area surrounding the Nolans site in 2010 to determine the existing, pre-mining noise levels in the area.

Unattended noise monitoring results included:

- Background LA90 dB(A) ranged from 26-28 dB(A) over 24 hour period
- Ambient L_{Aeq} dB(A) ranged from 34-45 dB(A) over 24 hour period.

These results were typical of a rural environment with birds and nearby insects influencing the ambient noise. The Stuart Highway traffic noise was faintly audible and intermittent during monitoring at Aileron Roadhouse.

Human sensitive receptors near the mine site include:

- Aileron Roadhouse 13 km to the south east
- Annas Reservoir 10 km to the west
- Accommodation village 9 km to the south east.

Acoustic modelling was undertaken to predict the effects of industrial (operational) noise generated by the project.

Applicable construction noise criteria for the project is 48 dB(A)Leq(15min) and applicable operational noise criteria is 35 dB(A)Leq(15min).

Potential noise impacts

The potential noise, airblast and ground borne vibration impacts from the site during the construction and operation of the project on human and fauna receivers is predicted to comply with the adopted criteria at all noise sensitive receivers.

Noise impact from the operation of the Nolans Project is summarised in the table below.

The operational noise impact at the Aileron Roadhouse and Annas Reservoir are expected to be below the noise criterion, but potential 10 dB(A) exceedance is predicted to occur at the accommodation village receiver with the gas turbine stacks at the power station site as the primary contributors.

Design of the turbines will include installation of a noise attenuator (silencer or equivalent) at the gas turbine exhaust stacks. The installed attenuator should achieve an overall noise reduction level of 20 dB(A) or more to the stack noise levels.

Predicted operational sound pressure levels dB(A)

Nearest sensitive receiver locations [1]	Project noise criteria dB(A) $L_{Aeq(15min)}$	Predicted noise levels dB(A) $L_{Aeq(15min)}$	Comply	Predicted noise levels with noise attenuator dB(A) $L_{Aeq(15min)}$	Comply with mitigation
Accommodation village	35	45	No	34	Yes
Aileron Roadhouse	35	12	Yes	8	Yes
Annas Reservoir	35	< 5	Yes	13	Yes

Note 1. Prediced for all periods

Traffic noise from the project is not expected to cause an impact at sensitive receivers, due to the substantial distance separation between the access roads and the sensitive receivers.

Socio-economic impact assessment

Socio-economic impact assessment (ESIA) considers the impacts on people, families and communities including impacts on lifestyles, way of life and livelihoods arising from the project.

The Northern Territory Government has a goal of reducing the disadvantage of remote Aboriginal communities through regional economic development, getting children to school and attracting private sector investment into strategic infrastructure that supports a North Australia Development agenda.

Central Desert Regional Council (CDRC) covers an area of about 282,093 km^2. It includes Ti Tree, Yuelamu, Laramba and Engawala within the Anmatjere Ward. The CDRC is a significant employer in smaller communities.

The Central Land Council (CLC) is a Commonwealth statutory authority operating under the *Aboriginal Land Rights (Northern Territory) Act 1976* (ALRA) and a Native Title Representative Body acting under the *Native Title Act 1993* (NTA). CLC represents the interests of native title holders.

Population and communities

The population of the Northern Territory as at June 2014 was 245,100, or 1.0 per cent of Australia's population. Of the Territory's Aboriginal population, 21.4 per cent lived in remote areas, 28.3 per cent in very remote areas and 20 per cent in outer regional areas.

The Alice Springs Local Government Area had a population of 28,667 in 2014, or 12 per cent of the Territory's population. A key demographic trend in Alice Springs is the major increase in overseas migrants moving to Alice Springs from other parts of Australia and directly from overseas since the 2011 Census.

The town acts as a service centre to the Alice Springs Region, or ABS SA3 area, which has a population of 41,700 (including Alice Springs) and covers the bottom half of the Territory.

In Central Australia more broadly, residents are predominantly Aboriginal, and the area is characterised by a high level of disadvantage across all socioeconomic indicators. The unemployment rate recorded in the 2011 ABS Census for the CDRC area was 14.4 per cent with a participation rate of 43.2 per cent, compared with 3.1 per cent unemployment and 61.4 per cent participation for the Alice Springs Local Government Area. The unemployment rate for the SA2 Yuendumu-Anmatjere area, which hosts the Nolans Project and is located wholly within the Alice Springs SA3 area, was 18.1 per cent in 2011.

Potential improvement in the socio-economic status of residents in Alice Springs and smaller Anmatjere communities, arising from business, employment and training opportunities on the project has the potential to impact positively on the broader population. Additionally, job creation could result in new population moving to the area in the form of workers and their immediate families, thus contributing to population growth in the Alice Springs local area.

There is also the potential that those same opportunities could impact negatively on community cohesion through:

- The influx of workers creating tensions with existing communities, relating to employment opportunities
- Tension arising from distribution of benefits, including wages and royalty payments, particularly management of cash payments.

Employment and economies

Nearly 40 per cent of jobs in the Northern Territory are in the government and community services. Tourism comprises 13 per cent of the workforce, construction 8.2 per cent of total employment, mining 4.3 per cent, and agriculture 1.1 per cent of the workforce.

The Alice Springs SA3 region supports a workforce of around 29,000 people of whom just over 1,100 are currently seeking work. This equates to around 24 percent of the workforce of the Northern Territory and 23 percent of all job seekers in the Northern Territory.

The project's potential contribution to productivity and real incomes and to job creation, both direct and indirect are documented in the EIS and include:

- Construction spend of $145 million in the Northern Territory including $71 million in the Alice Springs region
- An increase in real income of $717 million over the life of the project, including by $282 million in the Alice Springs region
- An increase in local employment opportunities leading to higher levels of employment, economic participation, improved education outcomes and reduced levels of disadvantage.

While the potential economic benefits are substantial, the potential impact from sourcing employees from local communities is uncertain given the small size of the available work-ready labour pool relative to the project's labour needs, particularly during construction. Recruitment of personnel for the project may draw staff from existing jobs in Central Australia, resulting in employment losses to local businesses.

Services and infrastructure

Services and community infrastructure in the region is provided primarily by the Northern Territory Government and CDRC, including policing, health and education, municipal services to communities as well as major infrastructure such as utilities, roads and telecommunications.

It is likely that both Alice Springs and nearby communities can absorb the project workforce without a great impact on existing services such as health, housing and emergency services, particularly as the fly in-fly out / bus in-bus out (FIFO/BIBO) workforce is planned to be largely accommodated at an onsite village.

The project will potentially create the opportunity for improved infrastructure that benefits local communities, particularly if the combination of the Nolans Project and horticultural expansion prompt the growth of Ti Tree as a regional economic hub. Benefits could include better telecommunications and essential services.

Health and wellbeing

Remote Aboriginal Northern Territory communities continue to reflect poorly against key determinants of health, which impact on school attendance and employment outcomes and individual health and wellbeing.

The project has the potential to result in reduced substance abuse, and increased health and wellbeing outcomes in Aboriginal and non-Aboriginal communities, due to employment and training opportunities and access to higher wages.

On the other hand, the project also has the potential to create additional substance abuse and mental health issues associated with the high wages and living away from home conditions prevalent in the resources industry.

A Community Relations Officer will work with communities and agencies to address any issues or complaints that may arise during operations. It is Arafura’s preference that the community benefits package to be negotiated with traditional owners will focus on broader economic and community benefit rather than solely on cash payments.

Cultural Heritage

Aboriginal and historic (non-Aboriginal) cultural heritage values of the study area have been documented, and the potential impacts on Aboriginal and historic heritage arising from project activities, assessed.

The term ‘cultural heritage’ includes, very broadly, all places and values of archaeological, traditional, historical or contemporary significance.

A review of the environmental, ethnographic and archaeological context of the study area was undertaken to identify the potential for any unknown objects and/or places of significance. A cultural heritage survey was undertaken during 2015 across the whole Nolans site, and across the mine site in 2006 and 2012.

No Aboriginal sites or places within the study area are currently subject to a Declaration under the *Aboriginal and Torres Strait Islander Heritage Protection Act 1984*, or listed on the National Heritage List or Commonwealth Heritage List.

Three places within ten kilometres of the study area are declared heritage places:

- Aileron Homestead
- Ryan Well Historical Reserve
- Annas Reservoir Conservation reserve

There are a number of sacred sites in the study area. Sacred sites are usually associated with creeks, waterholes, and/or geological outcrops; which archaeological survey has also found to contain archaeological materials and features.

The most common site features are quarries (exclusively in the vicinity of quartz outcrops) and artefact scatters, which are frequently recorded in association with the quarries; followed by scarred trees.

Overall 67 Aboriginal archaeological sites (including 34 isolated artefacts) have been recorded during archaeological surveys. The Yalyirimbi Range is a particularly archaeologically sensitive zone, as many of the largest archaeological sites were identified in the vicinity of strike ridges and rock outcrops.

The archaeological site and artefact assemblage distribution emphasises the importance of the Yalyirimbi Range to Aboriginal people in the past, based on the number of sites, and abundance and diversity of artefacts identified; however a high proportion of the archaeological sites have been impacted by pastoral land use and erosion.

The heritage significance of Aboriginal archaeological sites has been assessed using the four criteria outlined in the Australia ICOMOS Burra Charter: aesthetic, historic, scientific, and social or spiritual significance. Aboriginal sites recorded during the field survey were ranked from low to high archaeological significance. Of note are the following:

- Artefact scatters and an associated quarry with potential subsurface archaeological deposit
- Intact examples of artefact scatters and quarries
- Scarred trees which are regionally rare.

In addition, given that field survey covered approximately 12 percent of the study area, it is also likely that additional archaeological material is present. There is also potential for additional sub-surface archaeological materials, most notably in the creek banks of the alluvial plains.

Potential impacts on heritage

Without some form of mitigation, archaeological resources recorded in this survey will be impacted by the proposed infrastructure, particularly during the construction phase of the project.

A high proportion of the archaeological sites were located in association with specific features such as outcrops of gneiss domes and platforms, at the base of the steep ridges and over the lower gneiss foothills. Avoiding these types of landscape features, where possible, would reduce the risk of impacting unknown archaeological resources. Additionally, consideration of the level of significance of cultural heritage places and objects is important for determining appropriate impact management measures for sites.

A Cultural Heritage Management Plan will be implemented during project construction and operation and will include:

- Procedures to avoid significant sites and areas
- Procedures to protect key sites during construction, operation and decommissioning work
- Measures to enable the Proponent to meet its duty of care to protect the cultural and heritage values of any places or items of significance
- Procedures for the discovery and subsequent notification and management of surface or sub-surface items during the course of the project.

Traffic and transport

This component of the EIS analysed the impacts of the proposed Nolans Project on the road network at the intersection of Stuart Highway and the proposed access point to the site, and on local roads within Alice Springs where freight traffic to and from the site is likely to travel.

The site access alignment 5 km south of Aileron Roadhouse currently exists as an unsealed track, which will be upgraded to a two lane, two way sealed road during the construction phase of the project. Mine site consumables and rare earth intermediate products will be imported and exported respectively from/to Darwin via Alice Springs, using the Adelaide-Darwin railway and the Stuart Highway.

Based on the quantity of consumables required to be imported, the traffic generated by the project is expected to average of 26 daily one-way-trips. The forecast total daily generation of 26 vehicles and peak hour generation of 16 vehicles indicate that site operations are likely to result in a low impact on the existing road network.

An assessment of the requirements for the intersection of the site access road with the Stuart Highway indicates that basic auxiliary left/right treatments would be sufficient from a traffic capacity perspective; however the open speed limit on this section of the highway warrants a channelised treatment from the Stuart Highway into the site access road to improve road safety.

The project will have a low impact on the existing road network (including on the road pavement and the ability of the public to access essential services). No upgrades or modifications are required to support the project, apart from the upgrade of the site access intersection with the Stuart Highway.

The rail transport requirement for the project will have a negligible impact on capacity on the Alice Springs to Darwin rail freight line, and the project will not impede the availability of existing services to other users.

The closest port facilities are located in Darwin and Adelaide. Shipping options are available with rail connectivity at both Darwin (East Arm Wharf) and Port Adelaide. The Port of Darwin can provide access for the movement of containerised products, bulk materials and liquid bulk through the adjacent Vopak bulk liquids terminal and is the port favoured by the project.

Alice Springs Airport is located approximately 145 kilometres south of the proposed site access road on Stuart Highway. A large number of domestic flights depart from and arrive at Alice Springs Airport each day from capital cities and smaller regional airports in the Northern Territory.

Mine rehabilitation and closure

Planning for rehabilitation, decommissioning and closure for the whole-of-project has been initiated as a conceptual process and will be refined as the project progresses through detailed design and construction.

The overriding intent of mine closure and rehabilitation is to return the land to as close as is reasonably practical, its pre-disturbance condition. This will be achieved through establishment of a safe and stable post-mining land surface which supports vegetation growth and minimises erosion over the long-term.

The objectives of mine closure and rehabilitation are:

- To establish a safe and stable post-mining land surface which supports vegetation growth over the long-term
- To return the land, as close is reasonably practical, to its pre-disturbance land use
- To make the site suitable for use by future leaseholders.

Completion criteria provide a means of evaluating the successful achievement of closure objectives. The level of detail of completion criteria will be appropriate to the stage of development.

A conceptual Mine Rehabilitation and Closure Plan (MRCP) details the mine closure domains and describes the key closure landform concepts. The final, post-closure land use will be developed and refined through the operating life of the project.

Potential closure and rehabilitation impacts

The potential impacts arising from the closure of the Nolans Project site include both medium and low level risks. Medium level residual risks that will be addressed through the development of the mine closure planning process include:

- Unexpected early closure, before adequate closure and rehabilitation planning and design is in place
- Failure of operational practice leaves a legacy of difficult to manage waste facilities during closure
- Lack of available suitable low permeability material on site, or prohibitive cost of importing large volumes from elsewhere, prohibits the creation of appropriate capping for waste storage facilities, preventing long term stabilisation and containment of waste
- Ineffective closure designs and execution results in the failure of post-closure landforms and waste containment
- Incomplete remediation of contaminated sites resulting in harm to the surrounding environment and/or future land users
- Closure activities are poorly managed leading to impacts on local communities, flora, fauna, and water resources
- Rehabilitation fails to achieve sufficient vegetation to stabilise ground, allow proposed land uses or achieve target ecosystem recovery, due to inappropriate design or execution
- Seepage of site contaminants impacting surface and / or groundwater quality

- Overuse of groundwater during operation, changes to the groundwater regime caused by drawdown from evaporation at pit lake, and / or changes to recharge rates due to climate change, result in slower than predicted aquifer recovery
- Unauthorised site access / security breach during closure, leading to exposure of the public to hazards, ill health, injury or death
- Plant and / or equipment contaminated with ore or process materials leaving the site while still contaminated with radioactive or other hazardous material resulting in off-site radioactive or chemical contamination resulting in harm to the public.

A Mine Management Plan will establish a system by which environmental impacts are managed during operation, including maintaining the site so it can be closed and rehabilitated practicably and without creating additional environmental impacts. Key elements of operational management that will contribute to closure are:

- Acid Metalliferous Drainage Plan
- Process Plant Process Controls,
- Tailings Management Plan for tailings and process residue deposition
- Site management plans.

Abbreviations

Abbreviations

Term	Description
µg/m³	Micrograms per cubic metre
µGy/h	Micrograys per hour
µJ/m³	Microjoules per cubic metre
µm	Micrometre, or micron
µSv/h	Microsieverts per hour
µSv/y	Microsieverts per year
AADT	Average annual daily traffic
AAPA	Aboriginal Areas Protection Authority
AAPA	Aboriginal Areas Protection Authority
ABS	Australian Bureau of Statistics
AE Act	Atomic Energy Act
AIPA	Australian Industry Participation Authority
ALARA	As Low As Reasonably Achievable
AMD	Acid Metalliferous or Saline Drainage
ANCOLD	Australian National Committee on Large Dams Incorporated
ANFO	Ammonium nitrate fuel oil
ANSTO	Australian Nuclear Science and Technology Organisation (Australian Government)
ANZECC	The Australian and New Zealand Environment Conservation Council
ARI	Average recurrence interval
ARPANSA	Australian Radiation Protection and Nuclear Safety Agency (Australian Government)
ASL	Above sea level
ATSIHP	Aboriginal and Torres Strait Islander Heritage Protection Act
AUD or $	Australian dollars
BAL	Basic auxiliary left (turn treatment)
BAR	Basic auxiliary right (turn treatment)
BIBO	Bus-in/bus-out

Term	Description
billion	Billion measured by $1x10^9$ (or 1,000 million) as per the US convention
BMP	Biodiversity Management Plan
BOM	Bureau of Meteorology
Bq	Becquerel (one disintegration per second)
Bq/g	Becquerels per gram
Bq/kg	Becquerels per kilogram
Bq/L	Becquerels per litre
$Bq/m^2/s$	Becquerels per square metre per second
Bq/m^3	Becquerels per cubic metre
BRT	Burt Plain Bioregion
Ce	Cerium
CEO	Chief Executive Officer
CHMP	Cultural Heritage Management Plan
CHMP	Cultural Heritage Management Plan
CLC	Central Land Council
CO	Carbon monoxide
CSIRO	Commonwealth Scientific and Industrial Research Organisation
Cth	Commonwealth
dB	Decibel is the unit used for expressing the sound pressure level or power level in acoustics
dB(A)	Frequency weighting filter used to measure ‘A-weighted’ sound pressure levels,
DFS	Definitive feasibility study
DG Act	Dangerous Goods (National Uniform Legislation) Act
DG Reg	Dangerous Goods (National Uniform Legislation) Regulation
DLRM	Department of Land Resource Management (Northern Territory Government)
DME	Department of Mines and Energy (Northern Territory Government)
DMP	Dust Management Plan
DotE	Department of the Environment (Australian Government)

Term	Description
DSP	Double Sulfate Precipitation
EA Act	Environmental Assessment Act 1982 (Northern Territory Government)
EA Act	Environmental Assessment Act
EAD	Equivalent Aerodynamic Diameter
EIS	Environmental impact statement
EL	Exploration licence
EMEL	Extractive mineral exploration licence
EMP	Environmental Management Plan
EPBC Act	Environment Protection and Biodiversity Conservation Act 1999 (Australian Government)
EPCM	Engineering, procurement and construction management
ERICA	Environmental Risk from Ionising Contaminants: Assessment and Management
ESCP	Environment and Sediment Control Plan
ESD	Ecologically Sustainable Development
FIFO	Fly-in/fly-out
FMP	Fire Management Plan
FOPS	Falling object protection systems
g/m^2	Grams per square metre
$g/m^2/month$	Grams per square metre per month
GL	Gigalitre (billion litres)
GPS	Global positioning system
GSP	Gross State Product
GWA	Genesee Wyoming Australia (rail operator between Tarcoola (SA) and Berrimah (NT)
ha	Hectare
HDPE	High density polyethylene
HPRG	High pressure roller grinding
HV	High voltage
IAEA	International Atomic Energy Agency
ICN	Industry Capability Network

Term	Description
ICRP	International Commission on Radiological Protection
ILUA	Indigenous land use agreement.
ILUA	Indigenous Land Use Agreements
ISO	International Organisation for Standardisation
JORC	Joint Ore Reserves Committee
kg/y	Kilograms per year
km^2	Square kilometre
kV	Kilovolt (thousand volts)
L/s	Litres per second
$L_{A10(period)}$	The sound pressure level that is exceeded for 10% of the measurement period.
$L_{A90(period)}$	The sound pressure level that is exceeded for 90% of the measurement period.
$L_{Aeq(period)}$	Equivalent sound pressure level
Land Rights Act	Aboriginal Land Rights (Northern Territory) Act
LOM	Life of mine
LTS	Long term stockpile
M&I	Measured and Indicated (Mineral Resources)
m/s	Metres per second
m^3/day	Cubic metres per day
m^3/s	Cubic metres per second
mAHD	Australian Height Datum in metres
mASL	Metres Above Sea Level
MBq/s	Megabecquerel per second (million becquerels per second)
MCA	Minerals Council of Australia
mg/m^3	Milligrams per cubic metre
ML	Mineral lease
ML/y	Mega Litre per year (million litres per year)
Mlcm	Million loose cubic metres
MM Act	Mining Management Act
mm/s	Millimetres per second

Term	Description
MMP	Mining Management Plan
MMP	Mining Management Plan
MNES	Matters of National Environmental Significance
MRCP	Mine rehabilitation and closure plan
mSv	One thousandth of a sievert
mSv/y	Millisieverts per year
Mt	Million tonnes
MT Act	Mineral Titles Act
Mtpa	Million tonnes per annum
MW	Megawatt (million watts)
NAG	Net Acid Generation
NAPP	Net Acid Producing Potential
NdPr Oxide or Didymium Oxide	Neodymium and praseodymium mixed oxide
NE	North East
NGERA	National Greenhouse Energy Reporting Act
NNTT	National Native Title Tribunal
NO_2	Nitrogen dioxide
NORM	Naturally occurring radioactive material
NPI 2012	National Pollution Inventory emission estimation guidelines
NRETAS	Natural Resources Environment and the Arts and Sport
NT	Northern Territory (of Australia)
NT EPA	NT Environment Protection Authority
NTA	Native Title Act
NW	North West
OEM	Original equipment manufacturer
P_2O_5	Phosphate
PAEC	Potential alpha energy concentration
PAF	Potential acid forming
PAR	Population at risk

Term	Description
PAS	Personal air samplers
Pb	Lead
PEHA	Public and Environmental Health Act
PEHR	Public and Environmental Health Regulations
PFS	Preliminary feasibility study
PLL	Potential lives lost
PM_{10}	Particulate Matter 10 micrometres or less in diameter
PMF	Possible maximum flood
PMP	Probable maximum precipitation
PMST	Protected matters search tool
Po	Polonium
ppm	Parts per million
PPV	Peak Particle Velocity
Ra	Radium
RBL	Rating Background Level.
RE	Rare Earth
REO	Rare earth oxide
RL	Reduced level
RMP	Radiation Management Plan
Rn	Radon
Rn220	Radon isotope known as Thoron
Rn222	Radon isotope
RnDP	Radon decay product
ROM	Run of Mine
RPA	Radiation Protection Act
RQ	Risk Quotient
RSF	Residues storage facility
Sacred Sites Act	Northern Territory Aboriginal Sacred Sites Act
SAPL	Sulfuric acid pre-leach
SE	South East

Term	Description
SIA	Social Impact Assessment
SIMP	Social impact management plan
SO_2	Sulphur dioxide
Sv	Sievert
Sv/y	Sieverts per year
SW	South West
t	Tonne
TDG Act	Transport of Dangerous Goods Act
TDG Act	Transport of Dangerous Goods by Road and Rail (National Uniform Legislation) Act
TDG Regs	Transport of Dangerous Goods Regulations
TDG Regulations	Transport of Dangerous Goods by Road and Rail (National Uniform Legislation) Regulations
TEU	Twenty-foot equivalent containers (intermodal shipping container)
Th	Thorium
TLD	Thermoluminescent Dosimeter
TnDP	Thoron Decay Product
TOR	Terms of Reference
tpa	Tonnes per annum
TPWC	Territory Parks and Wildlife Conservation Act 2000
TREO	Total RE oxide
TSF	Tailings storage facility
TSP	Total suspended particulates
U	Uranium
U_3O_8 or UO_4	Uranium oxide
UNSCEAR	United Nations Scientific Committee on the Effects of Atomic Radiation
US	United States
UV	Ultra violet
V	Volts
VoIP	Voice over Internet Protocol

Term	Description
vpd	Vehicles per day
vph	Vehicles per hour
WA	Western Australia
WHIMS	Wet high intensity magnetic separation
WHS Act	Work Health and Safety (National Uniform Legislation) Act
WHS Regulations	Work Health and Safety (National Uniform Legislation) Regulations
WM Act	Weeds Management Act
WM Act	Weeds Management Act
WMP	Water Management Plan
WMPCA	Waste Management and Pollution Control Act
WRD	Waste Rock Dump
αdps/m^3	Alpha decays per second per cubic metre

Glossary

Glossary

Term	Description
Acidity	Latent acidity is a hidden stock of potential or future acid generation, based on a range of factors including local environmental geochemical conditions
AMD	A result of the exposure of some sulfide minerals to oxygen and water, resulting in drainage waters that can be acidic and/or have high concentrations of dissolved metals. The drainage produced from the oxidation process may be acidic or neutral, with or without dissolved heavy metals, but always contains sulfate.
Burra Charter	The Australia ICOMOS Charter for Places of Cultural Significance, 2013
Curtilage	The area of land occupied by a dwelling and its yard and outbuildings, actually enclosed or considered as enclosed
dB(A)	Frequency weighting filter used to measure 'A-weighted' sound pressure levels, which conforms approximately to the human ear response, as our hearing is less sensitive at very low and very high frequencies
Decibel	The unit used for expressing the sound pressure level (SPL) or power level (SWL) in acoustics
Endorheic basin	Closed drainage basin retains water and allows no outflow
Equivalent sound pressure level	The steady sound level that, over a specified period of time, would produce the same energy equivalence as the fluctuating sound level actually occurring
Gangue	Valueless rock or mineral aggregates in ore
Indigenous land use agreement.	A formal agreement under the Native Title Act that contemplates access to land for the purposes of mining, mineral processing, and the placement of associated infrastructure
JORC Code	Guidelines for public reporting of Exploration Results, Mineral Resources and Ore Reserves
Long term stockpile	Stockpiled ore scheduled for processing during life of mine
Mine site	Area comprising Mineral Lease Application ML 26659 lodged with the Northern Territory Government by Arafura in February 2008. Includes the mine, concentrator and associated infrastructure.
Mineral Resources	Defined under the JORC Code as concentration of solid material of economic interest in such form, quality and quantity that there are reasonable prospects of economic extraction

Term	Description
Mineral Titles Act	Legislation that regulates mineral exploration and mining titles in the Northern Territory
Monazite	A phosphate mineral that may contain up to 70 wt% REO
Nolans Bore	The Nolans Bore deposit, resource or mineral resources
Nolans Project or the project	Comprises the development of the proposed Nolans site
Nolans site	The collective term refers to the project site including all components - mine site, processing site, borefield area, accommodation village, access roads, utilities corridors (potable water pipeline, water supply pipeline, power lines)
Ore	Ore used in the context of this document is a generic term for mineralisation, or metal-bearing mineral or rock
Ore Reserves	Defined under the JORC Code as the economically mineable part of Measured and/or Indicated Mineral Resources
Processing plant	The plant within which the RE extraction processes are undertaken to produce the RE intermediate products
Processing site	Area comprising the processing plant, ancillary plants and supporting infrastructure
Pyrite oxidation	Pyrite oxidation by atmospheric and/or aqueous oxygen occurs through a complicated sequence of biologically mediated reactions
Rating Background Level.	The overall single-figure background level representing each assessment period (day / evening / night) over the whole monitoring period
RE extraction	Process converting RE concentrate to the RE intermediate product for RE separation
RE intermediate	The product from the RE extraction process in the form of a mixed RE compound which is the feed for the RE separation process
RE separation plant	Comprises the plant and associated ancillaries for processing RE intermediate to separated REO products. Note this will be an offshore plant and is not part of the EIS scope of work.
Reject gangue	Valueless rock or mineral aggregates in an ore
Section	A section reference within the report
Southern Basins	Northern Burt and Eastern Whitcherry basins
The project	Nolans Rare Earth Project

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01

Introduction

1. Introduction

1.1 Overview

Arafura Resources Limited (Arafura) is proposing to develop Nolans Project (the project) located approximately 135 kilometres (km) north west of Alice Springs, Northern Territory (NT) (Figure 1-1). The project is construction, mining, processing, rehabilitation and decommissioning of a rare earth (RE) mine and associated infrastructure.

The project is targeting a fluorapatite mineral deposit containing REs at Nolans Bore. The Nolans site comprises the mine site, a processing site, a borefield area and accommodation village site, and interconnecting access roads and utility service corridors (Figure 1-2).

Mining operations will be undertaken using conventional open pit methods (drill, blast, load and haul) at a maximum overall mining rate of ten million tonnes per annum (tpa), to produce an average one million tonnes of concentrator feed each year.

Excavated ore will be fed to beneficiation circuits at the mine site. The circuits will include staged crushing, grinding, wet magnetic separation and flotation. A concentrator will produce phosphate-bearing and RE-bearing concentrate in a slurry form. The slurry will be pumped via a high density polyethylene (HDPE) pipeline to the processing site approximately eight kilometres to the south of the mine site.

The processing site contains RE extraction processing units, a sulfuric acid plant, process residue storage facilities (RSFs), evaporation ponds, a power station and other infrastructure to support the operation. From the processing site, RE concentrate will be transported to Port of Darwin, NT and subsequently, to an offshore RE separation plant. The RE separation plant will be in an established chemical precinct capable of meeting the reagent demands of the refining process; and subject to a separate approvals process. The offshore component is excluded from the scope of this Draft Environmental Impact Statement (EIS).

The project triggers assessment under the Commonwealth *Environment Protection Biodiversity Conservation Act 1999* (EPBC Act), controlling provisions 18 and 18 A (listed threatened species and communities) and 21 and 22A (nuclear actions) and NT *Environmental Assessment Act 1982* (EA Act), at the level of an EIS (refer to Appendix A and Appendix B).

This EIS is submitted to the NT EPA and DoE for assessment in accordance with relevant legislation.

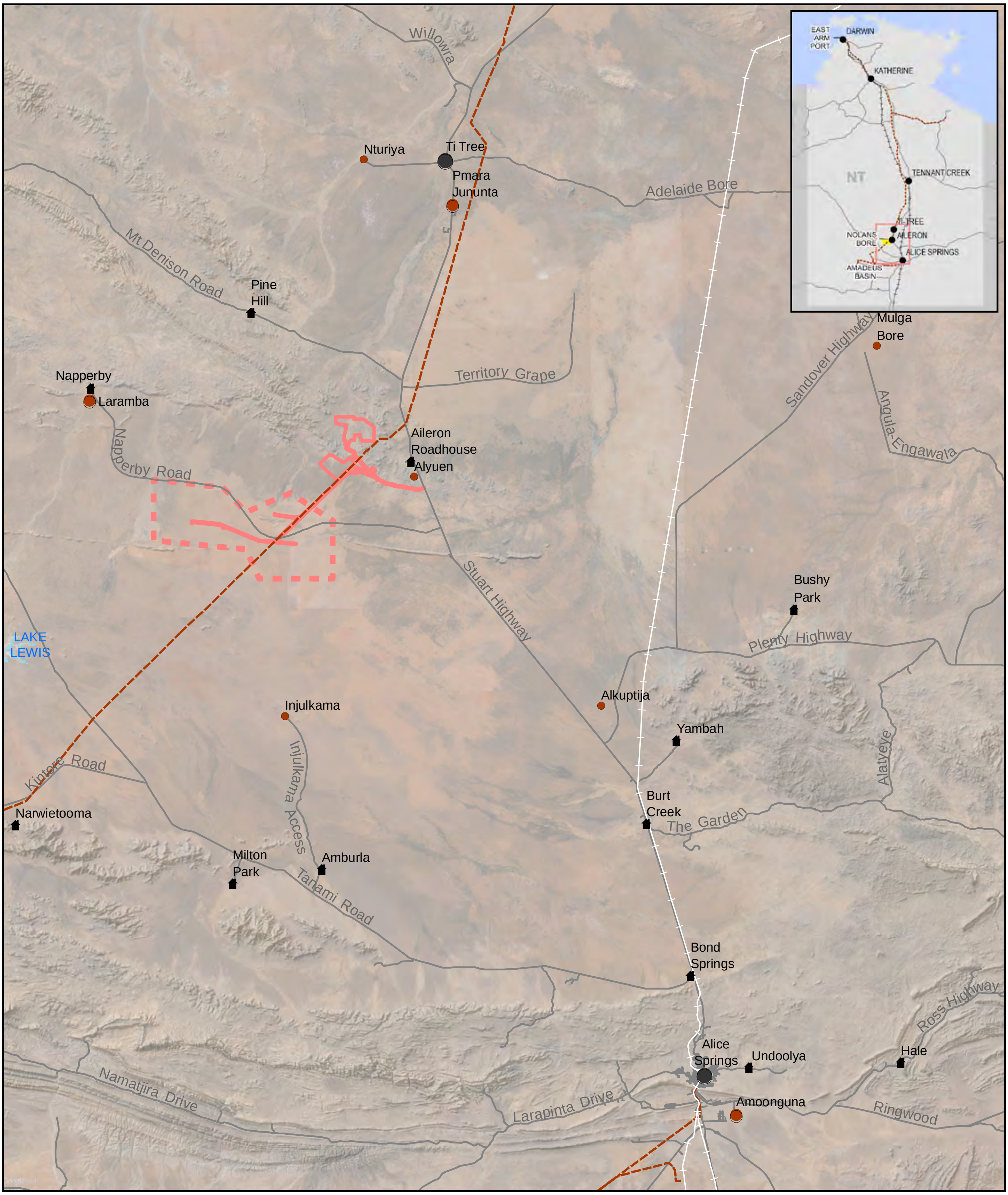
1.2 Proponent details

The project proponent is Arafura Resources Limited (Arafura or the Company or the Proponent). Arafura has a registered office in Perth, Western Australia, and an office in Darwin, NT.

The Proponent's contact for the project is:

Mr Brian Fowler
Arafura Resources Limited
General Manager Northern Territory and Sustainability
PO Box 37220, Winnellie, NT 0821
Phone: +61 8 8947 5588
Email: eis@arultd.com

Arafura has engaged independent consultants to prepare specialist technical studies as well as the main EIS report. The names of, work done by and the qualifications and experience of key persons involved in preparing the EIS are provided in Appendix C.



LEGEND

- Town
- Community
- Station
- Outstation
- Gas Pipeline
- Roads
- Project Areas
- Borefield Area
- Waterbodies

1:1,000,000 @ A4

0 10 20 30 40

Kilometres

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

N

ARAFURA RESOURCES LIMITED

GHD

Arafura Resources Limited
Nolans Project
Environmental Impact Statement

Job Number	43-22301
Revision	0
Date	13 Apr 2016

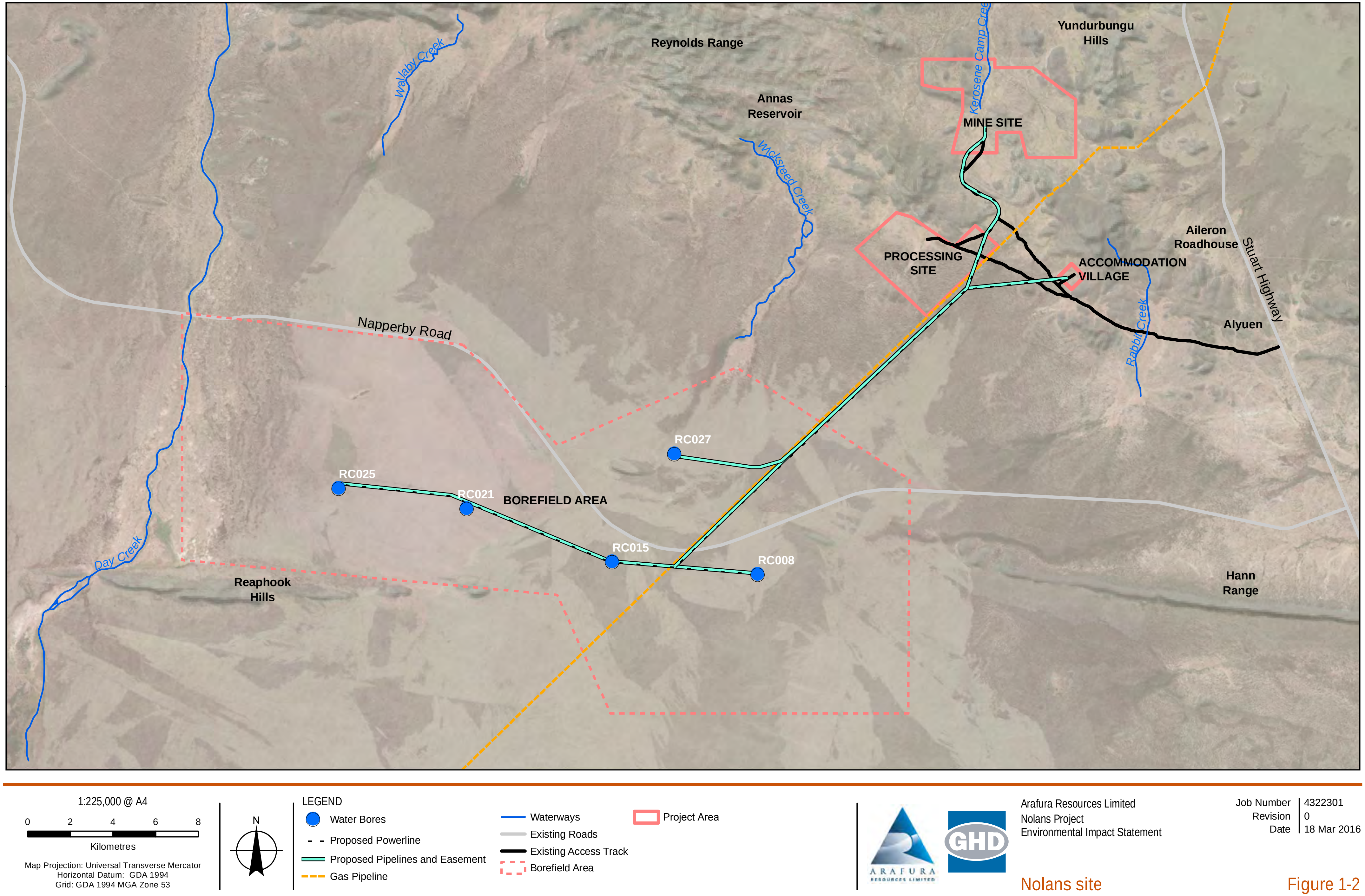
Project location

Figure 1-1

G:\43\22301\GIS\Maps\4322301_037_ProjectLocation.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: GA - Roads, Gas Pipeline, Waterways, Placenames, Placenames, Lakes (2015). ESRI - Shaded Relief (2009). Google Earth Pro - Imagery (Date extracted: 09/11/2015). ARL - Project Areas (2015). Created by: CM



Nolans site

Figure 1-2

G:\43\22301\GIS\Maps\4322301_003_NolansSite.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: GA - Imagery (2008), Roads, Waterways, Placenames (2015). ESRI - Shaded Relief (2009). ARL - Water Bores, Proposed Pipelines, Borefield Area, Proposed Mine Site, Treatment Plant and Accommodation Village (2015). Created by: CW, CM

1.2.1 Ownership and commodity information

Arafura is an emerging RE producer. The project will be the company's first mining and chemical processing operation. The Nolans Project is 100% owned by Arafura, an Australian stock exchange listed company.

Arafura is positioning itself to produce high quality RE products, and to target customers in key growth areas such as the automotive, clean energy technology and electronics sectors. In 2014 the global demand for RE products reached 126,000 tonnes, and this demand is forecast to grow at 5% per annum over next ten years; driven by technology innovation, particularly in industrial and clean energy sectors.

The project has the potential to supply 10% of the world's magnet feed demand through its production of NdPr (neodymium-praseodymium, or didymium) oxide. The use of REs in the permanent magnet sector is expected to grow by approximately 10% per annum.

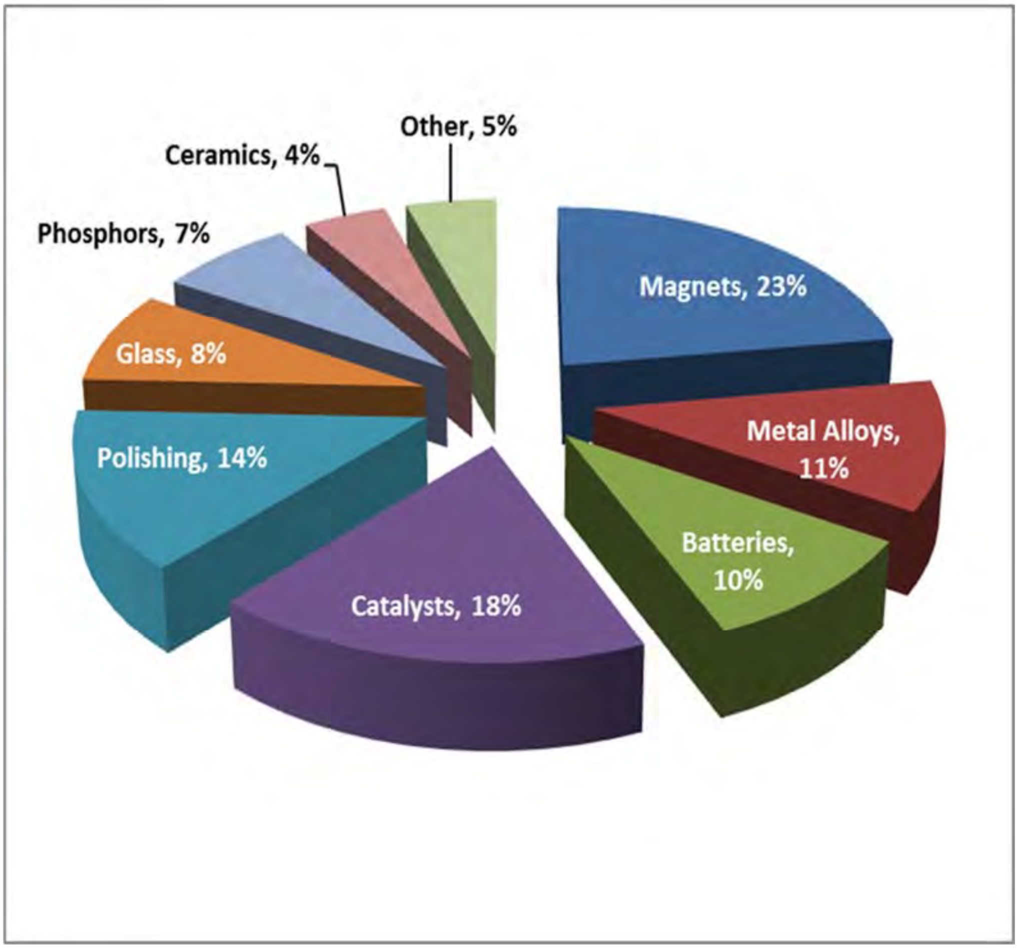


Figure 1-3 End uses of rare earth products (Arafura 2014)

1.2.2 Market position

Arafura's sales plan targets customers across the entire RE supply chain where visibility, security and stability of supply are becoming increasingly important. To position Arafura strongly in the regional markets of Europe, Japan, South Korea and North America, a combination of direct sales to end users and partnering with strategic distributors is important. Arafura has forged long-term relationships with key end users and strategic trading partners involved in key markets.

1.2.3 Key business dealings

Expertise in processing and marketing of REs resides in China. Arafura has recognised the need for strategic Chinese partnerships to enhance their access to RE expertise.

The East China Mineral Exploration and Development Bureau is a major state-owned enterprise and an important long-term strategic partner for, and shareholder in, Arafura. East China Mineral Exploration and Development Bureau has been the conduit through which Arafura has developed relationships with a number of Chinese RE producers, research institutes and investment groups, to help accelerate the development of the project.

Planning and project feasibility has progressed over a number of years as new information about the mineral deposit, processing technologies, project economics, RE markets and site conditions has developed.

1.3 Development context including project background

1.3.1 Project title

The recent and current name is the Nolans Project which is herein referred to as "the project". The project has previously been referred to as the Nolans Bore Project, Nolans Rare Earth Project, and Nolans Bore Rare Earth Mine.

1.3.2 Status of the project

The project is in the Definitive Feasibility Study (DFS) phase and Arafura is seeking environmental approval for the project.

In September 2014, Arafura released the Nolans Development Report (Arafura 2014). In December 2014 Arafura lodged a variation notification to the NT Environment Protection Authority (NT EPA) in accordance with the Section 14A "Procedure where proposed action altered" under the NT Environmental Assessment and Administrative Procedures under the EA Act. Pursuant to Section 14A of the Environmental Assessment Administrative Procedures, the NT EPA considered the alteration and determined that an EIS is necessary with respect to the project. Final Terms of Reference (TOR) for the preparation of an EIS (Appendix B) were issued in May 2015.

In February 2015, the Proponent also submitted a revised referral (EPBC 2015/7436) describing the changes to the proposed action to the Federal Minister for the Environment. In March 2015, the delegate of the Minister determined the project to be a controlled action (Appendix A) and that assessment and approval is required at a federal level. Triggers for assessment under Commonwealth legislation include the potential to have a significant impact on the following matters of national environmental significance that are protected under Part 3 of the EPBC Act:

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

The project is being assessed under a bilateral agreement between the Australian and NT Governments made under section 45 of the EPBC Act. Arafura is seeking approval under the EPBC Act and EA Act.

1.3.3 Project schedule

Arafura developed a detailed project execution plan for the Nolans Project in 2014, including planned commencement of construction in the second half of 2016 through to planned commencement of project operations in the first half of 2019 (Arafura 2014).

Construction of the mine, processing plant and associated infrastructure may take up to 30 months to complete. Pre-stripping will commence in Year 1 and provide construction materials for all proposed infrastructure.

1.3.4 Background

The Nolans Bore RE-phosphorus-uranium deposit was discovered in 1995 by PNC Exploration. The first exploration drilling was carried out at Nolans Bore in 2001 on Exploration Licence (EL) 9672, a predecessor tenement to Arafura's current EL 28473.

Systematic drilling of the site has been undertaken by Arafura since 2000. Nearly all of the exploration and resource definition activity has been confined to an area measuring 1.5 x 1.2 km, centred approximately on the-now decommissioned Nolan stock bore. This work indicates the widespread presence of RE-rich fluorapatite mineralisation at or near surface, within 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 in one part of the deposit has encountered mineralisation and alteration down to at least 430 metres (m) below surface (Arafura 2014).

In February 2008 Arafura applied for a Mineral Lease (ML) over the deposit and immediate surrounds (ML 26659; 1,404 hectares). In March 2008 a Notice of Intent (Arafura and GHD 2008) was submitted to the former NT Department of Natural Resources, Environment and the Arts (NRETA) for consideration under the EA Act. NRETA referred the project for assessment under the EA Act at the level of an EIS, and issued EIS guidelines for the project.

In August 2008, a referral (EPBC 2008/4371) under the Commonwealth EPBC Act was submitted to the former Department of Environment, Water Heritage and Arts. The Minister declared the project a "controlled action" under controlling provisions section 21 and 22A of the EPBC Act relating to a "nuclear action".

Planning of the project continued throughout 2010 and 2012, and extensions to the timeframe of the EIS guidelines were sought and granted by the NT environmental regulator.

Since 2008, the Nolans Bore mineral resource has approximately doubled and project requirements have altered, resulting in an expanded footprint that now includes a borefield, a downstream chemical processing operation at the processing site, and an accommodation village. As a result, additional ML applications were lodged with the NT Department of Mines and Energy (DME) to accommodate the expanded footprint of the project on ELs 28473, 28498 and 29509.

The project's 2008 post-beneficiation flow sheet has changed from a single complex, intended to be located at Whyalla in South Australia, to a split configuration comprising a processing plant at the Nolans site and an offshore RE separation plant in an established chemical precinct capable of meeting the reagent demands of the refining process.

A summary of the project's development in a global context is provided in Table 1-1.

Table 1-1 Summary of Nolans Project development context

Year	Project development context
1995	Discovery of Nolans Bore rare earths-phosphorus-uranium prospect by PNC Exploration
2001	Arafura acquires Nolans Bore exploration licence. First drill hole into Nolans Bore and maiden Joint Ore Reserves Committee (JORC) mineral resource (4 million tonnes).
2003	Arafura lists on the Australian Stock Exchange
2005	First metallurgical test program
2006	Australian Government grant ($3.3 million) for process development
2007	Pre-feasibility study: REs, phosphoric acid, uranium processing in the NT. China imposes RE export and production quotas.
2008	First environmental studies at Nolans site. Mine site mineral lease lodged. Global financial crisis.
2009	Chinese investment (24.86%) into Arafura. Process and configuration changes: REs, phosphate, uranium, gypsum processing in South Australia.
2011	Rare earth price bubble
2012	Major process breakthrough: first separated RE products. Major JORC mineral resource upgrade (47 million tonnes). Maiden JORC ore reserve (24 million tonnes).
2013	Rare earth prices collapse. Process and configuration changes: RE processing in the NT and offshore.
2014	Increased Chinese technical involvement in process development. Life-of-operation water supply secured. Processing site mineral leases lodged.
2015	EIS recommences on expanded project footprint. China removes RE export duties and quotas. Increase in JORC mineral resource (56 million tonnes).

1.3.5 Hydrogeological investigations

A hydrogeological investigation at the proposed Nolans mine site was completed in 2011 to estimate dewatering requirements during mining operations (Environmental Earth Sciences 2011).

In 2010-11 hydrological investigations to identify a sustainable water supply for the life of project initially focussed on potential groundwater supplies in the Cainozoic basins within about 40 km of Nolans Bore, and in particular, in the Ti Tree Basin aquifer to the northeast of the Nolans mine site.

In 2012 Arafura shifted its attention towards exploring the groundwater potential in the concealed and poorly constrained northern Burt and eastern Whitcherry basins (herein referred to as the “Southern Basins”) to the southwest of the mine site.

Arafura completed an exploratory water drilling program in the Southern Basins in late 2012 that successfully encountered groundwater in all exploration bores, including two bores in a high yielding thick sandstone aquifer.

A follow-up drilling campaign during mid-2014 included drilling through the entire Cainozoic sequence into the underlying basement units, and undertaking controlled pump testing of production bores sited in the best aquifers and dispersed across the entire area.

The Southern Basins area provides a sizeable, high-yielding, slightly brackish groundwater system that has the capacity to service the life of the operation, and therefore a viable sustainable alternative and preferred supply to the Ti Tree Water Control District.

1.4 Project location and regional context

1.4.1 Location and land tenure

The Nolans mine site is located 10 km west of the Stuart Highway, 65 km west of the Darwin-Adelaide railway, and 150 km by road from the major Central Australian town of Alice Springs (Figure 1-1). The Stuart Highway is the main highway from Adelaide to Darwin. The access road to the Nolans site is a proposed new sealed road.

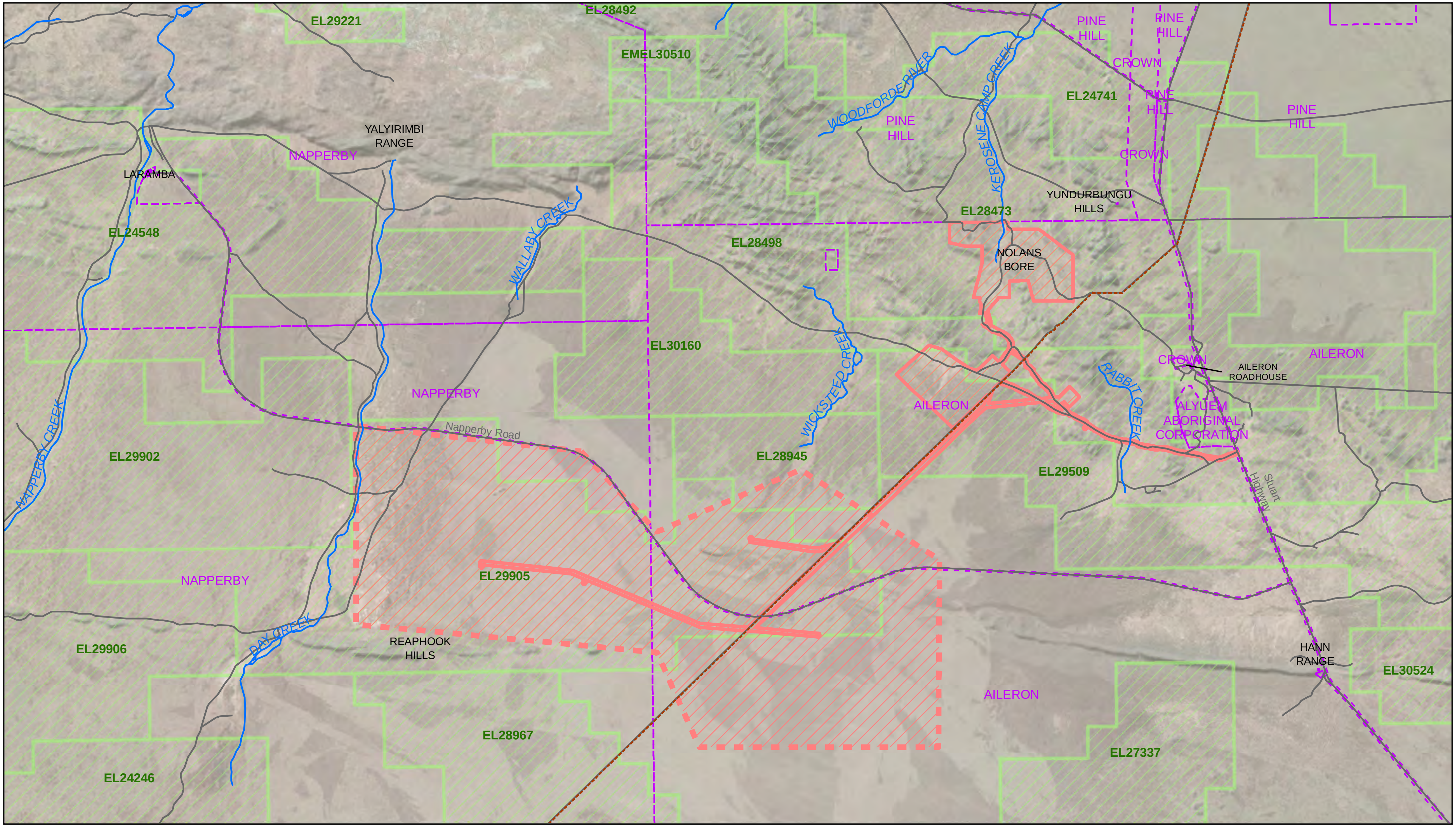
The Nolans site is located at latitude 22.565˚ south and longitude 133.239˚ east, within three granted ELs 28473, 28498 and 29509 (Figure 1-4).

Arafura has lodged applications for the following mining and ancillary tenements with the DME:

- ML 26659 over the mine site and
- MLs 30702, 30703 and 30704 over the processing site and accommodation village.

Aileron Pastoral Holdings Pty Ltd also hold background land tenure to the mine site and processing site under Aileron Perpetual Pastoral Lease (PPL 1097). The predominant land use on the pastoral lease is cattle grazing.

There may be a requirement for a separate Indigenous Land Use Agreement (ILUA) covering access to the borefield, which is situated some 35 km southwest of the mine site.



1:300,000 @ A4

0 2.5 5 7.5 10

Kilometres

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

N

LEGEND

- Gas Pipeline
- Waterways
- Roads
- Project Areas
- Borefield Area
- Pastoral Leases
- Exploration Licence

Arafura Resources Limited
Nolans Project
Environmental Impact Statement

Job Number	4322301
Revision	0
Date	13 Apr 2016

Land tenure

Figure 1-4

G:\43\22301\GIS\Maps\4322301_016_LandTenure.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: GA - Roads, Waterways, Gas Pipelines, Imagery (2015). DME - Mineral Titles (2015), DPLE - Tenure, Cadastre (2015). ESRI - SRTM (2006). GHD - Project Areas (2015). Created by: CM

The Adelaide to Darwin railway runs through Alice Springs. The rail corridor is located approximately 40 km east of Nolans site and the closest point. Arafura proposes to utilise the railway, accessing it at Alice Springs.

Daily flights between Alice Springs and most Australian capital cities eliminate the requirement for a dedicated airstrip at Nolans. The nearest paved and gravel airstrip to the Nolans site is at Ti Tree and Aileron Station respectively. The latter may be suitable for use by emergency aircraft following some upgrade.

The Amadeus Basin to Darwin natural gas pipeline passes directly adjacent to the Nolans processing site and within five kilometres of the mine site (Figure 1-1). The project will utilise gas during operation. A gas take-off line will be required to tap into the gas pipeline to service the site.

1.4.2 Major communications and community centres

The town of Alice Springs (population of about 26,000), south-southeast of the Nolans site along the Stuart Highway, is served by modern road, rail and telecommunications infrastructure. Traditional owners of the land on which Arafura will operate are Anmatjere people, with senior traditional owners living in the Alyuen, Ti Tree, Pmara Jutunta and Laramba communities and further afield in places such as Alice Springs (Figure 1-5). (Note that Anmatjere is also written Anmatyerr. Both spelling variations are utilised throughout this EIS).

Small communities and family outstations in the surrounding area include:

- Aileron Roadhouse - an important stop-over for travellers on the Stuart Highway, 12 km east of the Nolans site.
- Aileron Station – a 4,078 km^2 cattle station within which nearly the entire footprint of the Nolans Project is contained (with the exception of the western extent of the borefield and the Woodforde carbonate quarry). The property was acquired in July 2015 by Melbourne-based Aileron Pastoral Holdings Pty Ltd.
- Alyuen (Aileron) – a family outstation 130 km north of Alice Springs and two km west of the Stuart Highway (population about 20). It is located about 15 km south east of the Nolans site.
- Alkuptija (Gillians Bore) - a family outstation three kilometres west of Stuart Highway and 70 km south east of Nolans mine site (population about 20).
- Burt Creek (Rice's Camp) – a family outstation close to Stuart Highway and 93 km south east of Nolans mine site (population about 15).
- Injulkama (Amburla) – a family outstation 56 km south of Nolans mine site and 100 km to the north west of Alice Springs (population about 10).
- Laramba - a key community due to its relative proximity to the Nolans site and borefield. Access to the community is by the Napperby station road, which runs west from the Stuart Highway. The community is located approximately 50 km west of the Nolans site. Laramba is a large community of mostly Aboriginal people (population approximately 300) including some of the traditional owners of the Nolans site. It has a school, community health centre and other facilities.
- Napperby Station – a 5,356 km^2 cattle station, 50 km to the west which has been owned and operated by the Chisholm family since 1948. This includes a shared borefield area and Laramba community living area.

- Pine Hill Station – 2,686 km^2 cattle station bordering Aileron Station to the north. It hosts the proposed Woodforde carbonate quarry (not the subject of this EIS) and until recently was owned and operated by the Braitling family.
- Pine Hill (Anyumgyumba) – a small family outstation located near the Pine Hill Station homestead, 35 km west of the Stuart Highway and approximately 29 km north of the Nolans mine site. It has a small transient population.
- Pmara Jutunta (Six Mile) – a major community of about 190 people 46 km to the north east of Nolans mine site and close to the Stuart Highway and Ti Tree community.
- Ti Tree – a community located 170 km north of Alice Springs and 53 km north of the mine site, along the Stuart Highway. It is a large community with facilities including a school, health centre, library, police station and airstrip. Population is approximately 280 persons. Ti Tree serves as the operational centre for the Anmatjere Community Government Council.
- Nturiya (Ti Tree Station) is 17 km to the west of Ti Tree and has a population of about 100.

1.4.3 Landmarks

The Nolans mine site is at the head of the Kerosene Camp Creek valley on the north facing slopes of a northeast – southwest trending ridge of the Reynolds Range, whilst the processing site is situated on the southern slopes of the same ridge. Topographic elevation is 886 m above sea level (m ASL) at Mt Boothby to the east of the mine site, and 1,006 m ASL at Mt Freeling to the west. Most of the Kerosene Camp Creek valley floor at the mine site is typically between 650 and 700 m ASL whilst the processing site is at an elevation of about 670 m ASL (Figure 1-5).

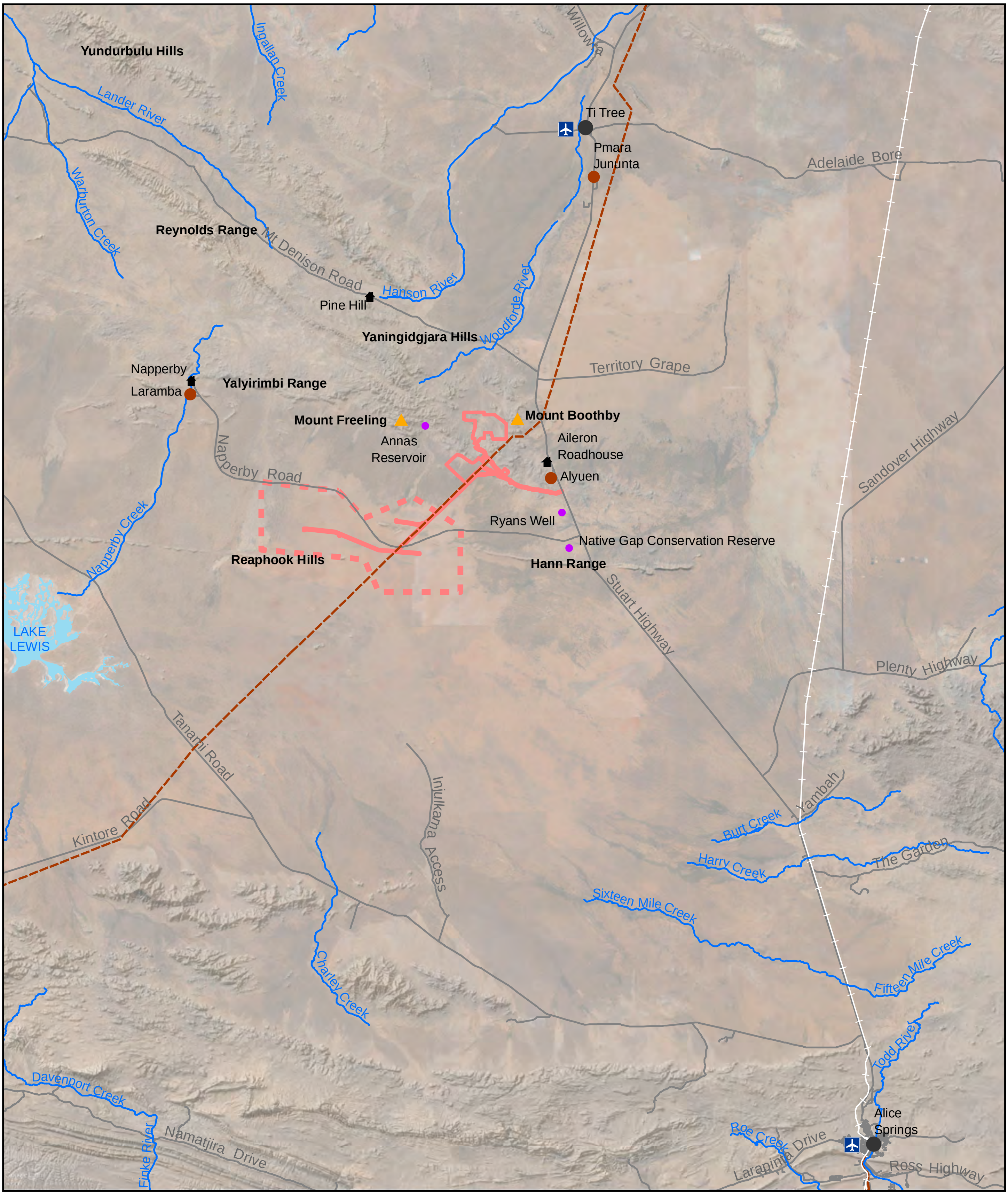
1.4.4 Water features

The important surface water drainage features within the Nolans site flow only immediately following rainfall events. Surface water flows originate in the catchments of the Reynolds Range and Yalyirimbi Range. These flows typically result in terminal creeks (i.e. their flow does not make it to a secondary water feature), including Gidyea Creek, Day Creek, Wallaby Creek, Wicksteed Creek, Kerosene Camp Creek, Rabbit Creek and Allungra Creek. Napperby Creek is the exception in that it discharges to the ephemeral Lake Lewis, following periodic high rainfall events. Likewise, the Woodforde River also discharges to the Hanson River downstream (north) of the study area. No significant surface water drainage features originate from the Hann Range, Reaphook Hills or in the low-lying dune country of the relatively flat plains of the Ti Tree Basin and Southern Basins.

The Nolans mine site is in the headwaters of the Woodforde River drainage system that flows across the south western fringe of the Ti Tree Basin. Kerosene Camp Creek is an ephemeral creek that flows through the centre of the mine site before joining the Woodforde River 10 km to the north. Nolans Creek is a major tributary of Kerosene Camp Creek that drains an area of 26 km^2 and flows adjacent to the eastern boundary of the proposed flotation tailings storage facility (TSF) and between two waste rock dumps (refer Chapter 3).

The processing site occupies a small part of the headwaters of several poorly defined creeks draining southwards into the Lake Lewis catchment. Distinct channels have not formed within these headwaters and runoff from the processing site is dispersed in minor rills.

The access road from the Stuart Highway to the Nolans site will cross the headwaters of numerous creeks draining southwards into the Lake Lewis catchment.



LEGEND

●	Town	Station		Roads		Project Areas	
●	Community	Site of Interest		Gas Pipeline		Borefield Area	
▲	Mountain	Airport		Waterways		Waterbodies	

1:900,000 @ A4

0 10 20 30

Kilometres

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

N

Arafura Resources Limited
Nolans Project
Environmental Impact Statement

Job Number | 43-22301
Revision | 0
Date | 13 Apr 2016

Land marks and water features

Figure 1-5

G:\43\22301\GIS\Maps\4322301_018_LandMarksWaterFeature.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: GA - Roads, Waterways, Placenames, Placenames, Lakes (2015). ESRI - Shaded Relief (2009). Google Earth Pro - Imagery (Date extracted: 15/12/2015). ARL - Project Areas (2015). Created by: CM

Water sampling in the Woodforde River indicates fresh but very turbid water, neutral in pH and with sufficient dissolved oxygen to support aquatic life. Conditions at the mine site may exhibit higher salinity and turbidity due to the lower volume of flow and dilution capacity. Baseline groundwater data indicates that aquifer discharge is not suitable for human consumption but is considered suitable as stock water.

Further details on surface water are contained in Chapter 7 and Appendix I. Further details on hydrogeology are contained in Chapter 8 and Appendix K.

1.4.5 Sites of cultural and/or social significance

A number of sites in the vicinity of the Nolans site have historical and/ or cultural interest. Sites on the National Reserve System closest to the project site (and the approximate distance at the closest point to the project site) include Annas Reservoir (7.5 km), Ryan Well (18.5 km) and Native Gap (28.5 km).

Annas Reservoir Conservation Reserve (Figure 1-5) played an important part in the overland journeys of nineteenth century explorers and settlers including John McDouall Stuart in 1860 and Alfred Giles in 1879. It was also a strategic water supply to the Overland Telegraph Construction team. In 1884 Annas Reservoir became the station homestead for the Barrow Creek Pastoral Company station (51,800 km^2) which was later abandoned.

Aileron Roadhouse is situated along the Stuart Highway about an hour and a half's drive north of Alice Springs and three and a half hours' drive south of Tennant Creek (Figure 1-5). The roadhouse hotel was established in 1936 to provide a stopover for travellers heading up and down the 'track'. Today the roadhouse continues to be an important stop-over providing various amenities tor travellers along the Stuart Highway.

Ryan Well Historical Reserve is close by (Figure 1-5) and contains a hand dug well from 1889 that was part of a pastoral settlement in the early twentieth century. Later in the 1930's, it became an important supply point for miners heading north-west to the 'Granites' gold rush.

Native Gap Conservation Reserve is a small roadside reserve located alongside the Stuart Highway between Alice Springs and Tennant Creek. The Reserve is of great importance to Arrernte and Anmatjere Aboriginal people (Figure 1-5), is a registered sacred site, is at the intersection of several creation-time stories and its name probably derives from the profile of a 30 m high sandstone ridge which dominates the site. It is also associated with the Overland Telegraph Line which was constructed through the area in the late nineteenth century.

Archaeological surveys carried out in 2006, 2010, 2012 and 2015 are described in detail in Chapter 16. Survey and assessment has identified a number of historic and cultural heritage items within, and in the vicinity of, the project area (within 100 m of proposed infrastructure), including 63 Aboriginal archaeological sites, 76 isolated artefacts and one potential historic site. Aboriginal site features include artefacts, quarries, scarred trees, grinding surfaces, reduction areas, a rockshelter, potential habitation structure, and engraving.

The potential historic site, Old Albs Bore and Yard, is associated with the pastoral history of Aileron Station, and consists of a water tank, stock yards, and a windmill.

1.4.6 Features of ecological significance

The Nolans site and part of the access road are within the Burt Plain bioregion (sub-region BRT1) (refer Chapter 9). The Burt Plain bioregion is a national priority bioregion for conservation planning and covers an area of about 73,800 km^2. The bioregion is very poorly reserved, and most ecosystems are not well represented, particularly mulga woodlands. The region contains five small conservation or historical reserves and one national park (Dulcie Ranges National Park) totalling 0.26% of the area of the bioregion.

The Department of Land Resource Management (DLRM) mapping shows no significant flora but indicates the presence of significant fauna in the immediate vicinity of the Nolans site and its access road including Rainbow Bee-eater (*Merops ornatus*), Glossy Ibis (*Plegadis falcinellus*), Bush Stone-curlew (*Burhinus grallarius*) and Redthroat (*Pyrrholaemus brunneus*).

Further details of the flora and fauna at the Nolans site are in Chapters 9 and 10 and Appendices M and N.

1.4.7 Other proposals or actions associated with this project

Carbonate material is required for acid neutralisation and pH control on the project. Arafura has secured exploration title (EMEL 30510) over a sizeable carbonate deposit located on Pine Hill Station north of the Woodforde River (Figure 1-4).

The deposit comprises fine to medium-grained marble and marly limestone. The carbonate unit dips moderately to the north and northeast and is assumed to continue with depth. Sampling has indicated that this material has suitable acid neutralisation capacity for use at the processing site.

The annual requirement of carbonate material will be nominally 125,000 tpa delivered to the processing plant, some 35 km to the south west.

It is anticipated that the carbonate will be mined by conventional quarrying methods using suitable bench heights to a maximum depth of around 50 m (although this can be extended if necessary). The quarry width at the natural surface will be around 100 m.

Arafura will seek a contractor to undertake the following scope of work:

- Drill and blast 125,000 tonnes of carbonate material at the Woodforde quarry each year.
- Crush and screen the blasted material.
- Load and haul the crushed carbonate product to the processing site, a distance of approximately 35 km.
- Construct a haul road of a standard suitable for the size and type of haulage units proposed by the contractor.
- Maintain two stockpiles of 20,000 tonnes of carbonate at the processing site and a similar stockpile at the Woodforde quarry.
- Provide site power, all water, fuel, lubricants, ground engaging tools and spares for the nominated equipment.
- Provide all necessary personal protection equipment, safety equipment, safe working procedures and licensing for the proposed operation.
- Provide adequate meals and accommodation for the contractor’s nominated workforce.

The proposed Woodforde quarry and haul road from the quarry to the Nolans processing site are not included in the scope of this EIS, but are described with reference to other exploration activities and/or areas that may be mined in the future, or other potential future actions planned. A separate regulatory approval will be sought for the quarrying operation in the future.

1.4.8 Other proposals and actions in the region

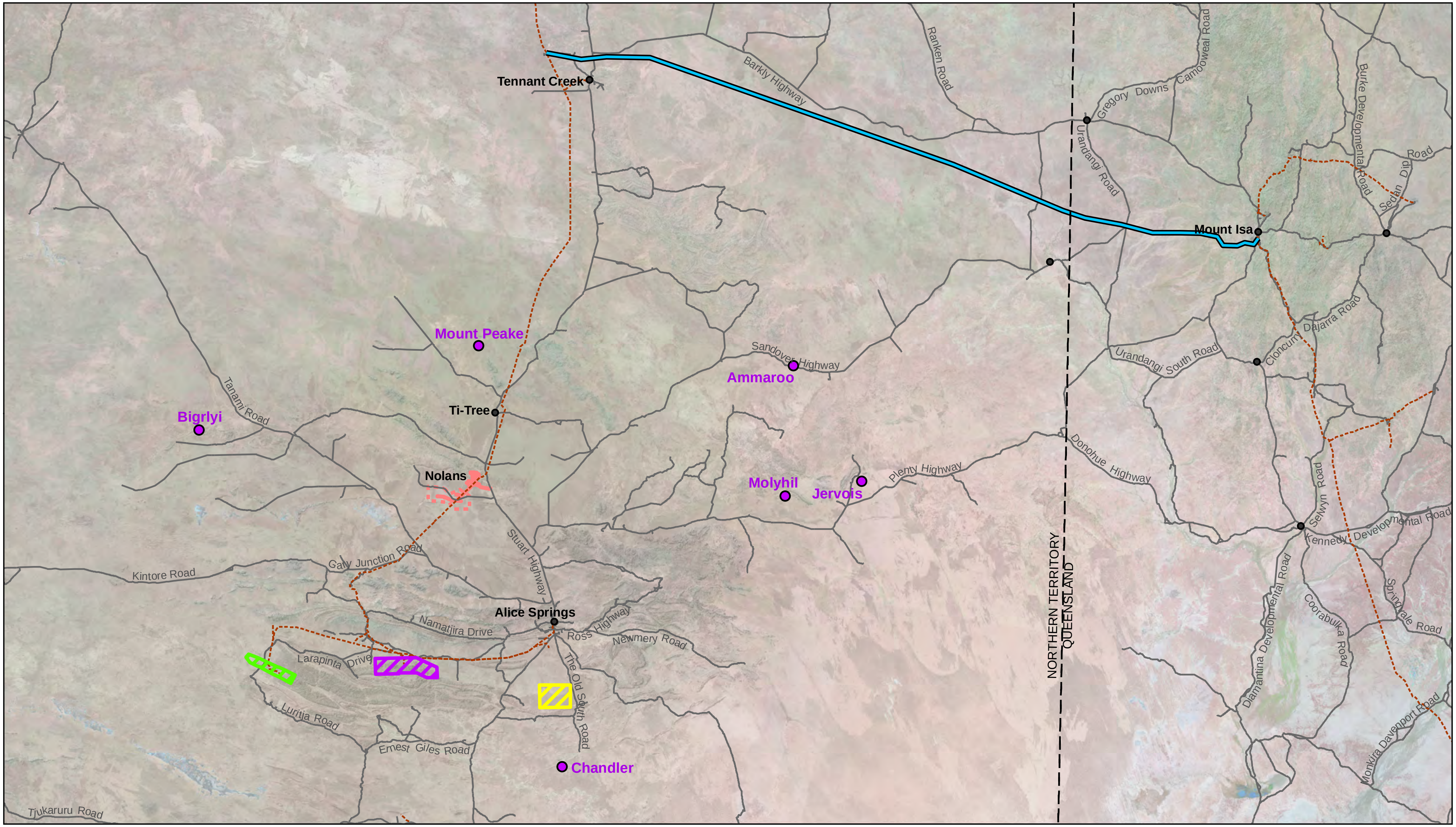
There are a number of potential mining, mineral processing operations, gas fields and gas pipeline opportunities that are proposed for the Central Australian region (Figure 1-6). The proposed operations lie within 400 km of Nolans site. Table 1-2 is reproduced from the Northern Territory Government’s March 2016 publication “Mining Developments in the Northern Territory”.

Some of these projects/ potential projects have a similar development timeline to the Nolans Project and have the potential to compete with Arafura for infrastructure investment and skilled human capital.

In addition to the above listed proposed resource developments, Central Petroleum Limited has in recent years acquired natural gas production assets in the Amadeus Basin, including the 100% ownership of the Palm Valley and Dingo gas fields; and 50% ownership of the Mereenie oil and gas field in a joint venture with Santos. Central provides established customers with gas via the Amadeus Basin to Darwin natural gas pipeline.

Jemena Northern Gas Pipeline Pty Ltd proposes to construct and operate a high pressure underground gas pipeline between the Amadeus Gas Pipeline commencing at Warrego approximately 45 km north-west of Tennant Creek, and the Carpentaria Gas Pipeline near Mount Isa. The pipeline would be 622 km in length; with approximately 457 km in the NT.

Chapter 4 provides discussion on potential cumulative impacts in the region.



1:4,250,000 @ A4

0 25 50 75 100

Kilometres

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

N

LEGEND

- Towns and communities
- Other Projects within 400 km of Nolans Project
- Northern Pipeline Project
- Gas Pipeline
- Roads
- Project Area
- Palm Valley Gas Field
- Dingo Gas Field
- Mereenie Oil Gas Field

Arafura Resources Limited
Nolans Project
Environmental Impact Statement

Job Number 4322301
Revision 0
Date 13 Apr 2016

Other Projects within 400 km of Nolans Project

Figure 1-6

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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: GA - Roads, Placenames, Imagery (2015). DME - Other Projects (2016), ESRI - SRTM (2006). GHD - Project Areas (2015). Created by: CM

Table 1-2 Mining and mineral resource actions and proposals in the region (NTG 2016)

Mine	Information
Ammaroo	
Company	Rum Jungle Resources Limited
Location	200 km south east of Tennant Creek
Description	New mine including open cut strip mining operations with crushing and screening to produce Phosphate Rock Concentrate for export or conversion to phosphoric acid for export or further conversion to ammonium phosphate fertilisers.
Product	Rock phosphate, phosphoric acid or ammonium phosphate fertilisers
Resource	Global Resource of 1.145 billion tonnes @ 14% P_2O_5 (10% cut-off) or 338 Mt @ 18% P_2O_5 (15% cut-off) Measured Resource of 138 Mt @ 15.7% P_2O_5 (10% cut-off)
Mine Life	25 years plus (potentially as much as 100 years)
Approvals	Environmental – in progress Mining – pending environmental approvals
Proposed Schedule	Pre-Feasibility completed in September 2014. Securing strategic industry investor. Construction – 2017/18 and Production – 2018/19
Jobs	Construction – TBC Production – 110-300
Capex	A$500M to A$1.8B depending on product and associated deployment
BIGRLY	
Company	Energy Metals Limited
Location	Approximately 340 km NW of Alice Springs
Description	Potential open pit and underground mining with on-site processing through simple acid leach circuit.
Product	Uranium
Resource	7.5 Mt @ 0.13% U_3O_8 for 21.1 M lbs U_3O_8 & 19.7M lbs V_2O_5 3.63 Mt @ 0.14% U_3O_8 for 11.2 Mlbs U_3O_8 & 15.7 Mlbs V_2O_5
Mine Life	Pre-Feasibility Study (PFS) based on 8 years
Approvals	Development proposals yet to be submitted.
Proposed Schedule	Results of Pre-Feasibility Study released in June 2011. Feasibility and environmental studies continue. Construction and Production – TBA

Mine	Information
Jobs	Construction – TBA Production – TBA
Capex	A$181M (from Pre-Feasibility Study).
Chandler	
Location	Approximately 120 km south of Alice Springs
Description	New Underground multi-mineral salt mine utilising standard mining technology, access via decline, room and pillar using a continuous miner. Voids left from mining used for storage. Surface facilities include salt processing plant (wet & dry), offices, camp and airstrip.
Product	Industrial and edible salts, associated minerals (fertilizer) & storage/disposal
Resource	309 Mt Halite (NaCl) JORC Measured Resource = 525 year mine life
Mine Life	25 years extendable
Approvals	Environmental – in progress Mining – Pending environmental
Proposed Schedule	DFS stage 1 (FEL2) completed in June 2014. DFS (FEL3) due in 2016. Construction (Darwin East Arm) – Q2 2016 Storage – Q4 2016 Construction (Chandler siding) – Q4 2016 Storage – Q3 2017 Construction (Mine) – Q2 2017 and Production – Q4 2021
Jobs	Construction – 280-350 Production – 180
Capex	A$648.7M
Jervois	
Company	KGL Resources Limited
Location	Approximately 270 km north-east of Alice Springs
Description	Reopen old mine based on open cut for first 4 years and underground operation from years 4 to 8. Sulphide ore processed via a conventional flotation processing facility to produce a copper concentrate. A second product of lead zinc concentrate will also be produced in certain ore zones.
Product	Copper concentrate with bismuth, silver & gold credits plus a separate lead and zinc concentrate with bismuth, silver & gold credits.

Resource	30.5 Mt @ 1.1% Cu & 23 g/t Ag (includes 113,000 oz gold & 190 kt Pb/Zn)
Mine Life	8 years+
Approvals	Terms of Reference for EIS issued May 2014. EIS being prepared.
Proposed Schedule	Pre-Feasibility Optimisation Study released October 2015. Construction – Q3 2017 and Production – Q4 2018
Jobs	Construction – Peaking at about 360 Production – Peaking at about 300
Capex	Initial CAPEX A$189.5M
Molyhil	
Company	Thor Mining PLC
Location	220 km northeast of Alice Springs
Description	Proposed open pit mining operation with on-site processing by flotation to produce W and Mo concentrate. Definitive Feasibility Study completed in July 2012 with upgrade in January 2015. Letter of Intent signed for tungsten offtake.
Product	Tungsten and Molybdenum concentrates.
Resource Reserve	4.71Mt at 0.4% combined WO_3 and Mo 3.0 Mt at 0.31% WO_3 and 0.12% Mo
Mine Life	Initially 6 year
Approvals	Environmental – November 2011 Mining – pending assessment of MMP
Proposed Schedule	Development subject to obtaining project finance
Jobs	Construction – 60 Production – 70
Capex	A$70M
Mount Peake	
Company	TNG Limited
Location	235 km north of Alice Springs

Description	Open pit mining and onsite processing to produce a magnetite concentrate. Concentrate railed to processing site near Darwin to produce high purity iron, vanadium and titanium products. New processing technology developed.
Product	High purity Vanadium (99% V_2O_5), Titanium Pigment & Pig Iron
Resource	160Mt @ 0.3% V_2O_5, 5% TiO_2, 23% Fe (120Mt Measured JORC)
Mine Life	Approximately 20 years
Approvals	EIS submitted February 2016 and available for public review through March 2016. MMP yet to be submitted. Separate development proposal and approval process for proposed Darwin Refinery.
Proposed Schedule	Definitive Feasibility Study completed July 2015. Construction (Mine) – Q3 2016 Production (Mine) – Q2 2018
Jobs	Construction (Mine) – up to 350 Production (Mine) – 175 to 250
Capex	A$970M for Stage 1 A$792M for Stage 2 (from DFS)

1.5 Structure of the EIS

The structure of the EIS is based on a combination of:

- Addressing and following the order of the NT EPA TOR where relevant
- Addressing potential environmental project risks identified in the NT EPA TOR and the environment project risk assessment (Chapter 5 of this EIS and Appendix F and G) and
- Presenting information in an order that aims to set the context for the reader and provide a logical sequence of information.

A summary overview of the structure of the EIS is below.

Chapter 1 - Introduction
Chapter 1 provides an overview and background to the project, proponent details, and context and setting of the project location.
Chapter 2 – Regulatory context
Chapter 2 summaries legislation and key guidelines that apply to the project and Arafura's approach to environmental management.
Chapter 3 – Project description
Chapter 3 provides a detailed description of the proposed action assessed in the EIS and for which Arafura is seeking environmental approval.
Chapter 4 – Project alternatives and cumulative impacts

Chapter 4 provides a high level summary of alternatives to various aspects of the project considered by Arafura throughout the development of the project. Cumulative impacts that may arise from projects being undertaken by other companies is summarised.

Chapter 5 – Risk assessment

Chapter 5 includes a description of the risk assessment method undertaken for the environmental and human health aspects of Nolans Project. A summary of the risk assessment is included. The content of the EIS is largely based around addressing the identified higher risks.

Chapter 6 – Community consultation

A summary of community and stakeholder consultation is included in this chapter. Key themes and matters raised during consultation are summarised. The content of the EIS is also aimed at addressed key themes raised by the community.

Chapter 7 – Surface water

The surface water chapter provides a description of key surface water features and functions in vicinity of the project and how the project may impact the existing environment. Potential mitigation measures are recommended.

Chapter 8 - Groundwater

The groundwater chapter provides a "water story" to understand the groundwater resources of the area and their users, potential impacts to groundwater from the project and relevant mitigation measures.

Chapter 9 – Biodiversity

The Biodiversity chapter includes a description of existing flora and fauna of the project area, threatened species listed in the NT only, context for threatened species listed under the EPBC Act, discussion about potential impacts in the project life of mine (LOM) envelope and mitigation measures.

Chapter 10 - Protected Matters under the EPBC Act

This chapter focuses on matters protected under the EPBC Act including matters of national environmental significance (MNES), particularly certain threatened species that triggered assessment under the EPBC Act. The intention of this chapter is to assist the Department of the Environment in assessing information relevant to their jurisdiction (combined with Chapter 12 Radiation).

Chapter 11 – Human health and safety

This chapter addresses the potential impacts to human health and safety associated with all stages and components of the Nolans Project. It includes risks to the workforce and the general public for the duration of the project, including post-closure, as required in the TOR for the project.

Chapter 12 – Radiation

Chapter 12 provides an overview of the radiological environment of the Nolans Project including a summary of the natural levels of background radiation in the region and impacts from operating the project on workers, the public and the environment. This chapter also address potential impacts on environmental air quality resulting from radon gas and other radioactive emissions.

Chapter 13 – Air

This chapter addresses potential impacts on air quality resulting from dust and processing plant emissions for all stages of the project.

Chapter 14 – Noise and vibration
A study of key noise and vibration generating activities of the project, and how they may impact nearest human sensitive receptors, is summarised in Chapter 14.
Chapter 15 – Socioeconomic
This chapter provides a summary of the project's social impact assessment and economic assessment describing potential benefits and consequences to the socioeconomic environment.
Chapter 16 – Historic and cultural heritage
Chapter 16 includes a summary of known indigenous and cultural heritage sites and items/objects, their potential significance and potential impacts and mitigation. At the request of the Central Land Council, sacred site mapping is not included in the public record due to cultural sensitivities.
Chapter 17 – Transport
In this chapter, key transport movements to and from Nolans site, and the contribution of the project to the transport network is assessed.
Chapter 18 – Rehabilitation, decommissioning and closure
A conceptual framework, objectives and risks for/of rehabilitation, decommissioning and closure are discussed in Chapter 18.
Appendices
Key supporting documents and/or technical reports that are the foundation of the EIS chapters are included as appendices. They include more detail about methods, guidelines, assumptions, calibration, monitoring considerations and concept management plans. The management plans are live documents and will be updated throughout various phases of the project as required by regulators (and Arafura management), in the event the project is approved and Arafura proceeds.

02 Regulatory context

2. Regulatory context

2.1 Commonwealth legislation

2.1.1 Aboriginal Land Rights (Northern Territory) Act 1976 (Cth)

The *Aboriginal Land Rights (Northern Territory) Act 1976* (Cth) (Land Rights Act) governs the grant and administration of Aboriginal land in the Northern Territory. Aboriginal land is a form of freehold estate vested in Aboriginal Land Trusts. The Land Rights Act empowers Land Councils to administer Aboriginal Land Trusts and provides that Land Councils are to consult traditional Aboriginal owners in relation to proposals that affect Aboriginal land.

Subject to Commonwealth powers, an estate or interest in Aboriginal land, or an exploration licence / permit affecting Aboriginal land, may only be granted with the consent of the relevant traditional Aboriginal owners of that Aboriginal land (Sections 19 and 40). The Land Rights Act also mandates the protection of sacred sites.

Each of the Northern Territory's four Land Councils also has statutory functions with respect to land within their administrative boundary. The functions of a Land Council include:

- assisting Aboriginals in taking measures likely to assist in the protection of sacred sites
- protecting the interests of traditional Aboriginal owners in land
- ascertaining and expressing the wishes and the opinion of Aboriginals living in the area of the Land Council with respect to land (Section 23).

The subject area is within the administrative boundary of the Central Land Council (CLC). The CLC has recorded sacred sites in the subject area.

The subject area is not located on Aboriginal land.

2.1.2 Aboriginal and Torres Strait Islander Heritage Protection Act 1984 (Cth)

The *Aboriginal and Torres Strait Islander Heritage Protection Act 1984* (Cth) (ATSIHP) assists in the preservation and protection of Indigenous heritage.

ATSIHP empowers the Federal Minister administering the Act to make declarations to preserve and protect from a threat of injury or desecration those areas and objects of particular significance to Aborigines in accordance with Aboriginal tradition (Section 4). An Aboriginal person or group can make an application to the Minister and the Minister may make an emergency declaration or a declaration for any period of time (Sections 9-12). The Minister's decision is personal and discretionary.

The Federal Minister must not make a declaration under ATSIHP if satisfied that a State or Territory law provides effective protection of areas or objects from threats (Section 13). ATSIHP is therefore only relevant where the relevant State or Territory's Aboriginal heritage protection regime is inadequate.

No places within the subject area are currently subject to a declaration under ATSIHP.

2.1.3 Atomic Energy Act 1953 (Cth)

The *Atomic Energy Act 1953* (Cth) (AE Act) vests ownership in the Commonwealth of prescribed substances located in the Northern Territory (Section 35). Prescribed substances are uranium, thorium, *and* similar radioactive substances including associated derivatives or compounds, *or* otherwise as prescribed by regulation *(Section* 5).

The AE Act also regulates the discovery of prescribed substances in the Northern Territory including making it an offence not to provide notification of such discoveries to the relevant Federal Minister (Section 36).

The Federal Minister has powers under the AE Act to require a person to report on prescribed substances within a person's control, on a person's land or in relation to work carried out in connection with the production or use of prescribed substances (Section 37).

2.1.4 Australian Jobs Act 2013 (Cth)

The *Australian Jobs Act 2013* (Cth) requires major projects, both private and public, with a capital expenditure of $500 million or more to develop an Australian Industry Participation (AIP) plan and provide it to the Australian Industry Participation Authority (AIPA). There are also requirements to notify the AIPA about the project, project proponents and certain events. The definition of eligible facility (section 6) may apply to the project.

An AIP is required to be lodged at least 90 days before the trigger date, defined to mean the earliest trigger event (Section 13). Trigger events include developing diagrams, developing flow diagrams, contracting/procurement, preparing an equipment list, sourcing or scoping goods and services, or making an environmental submission in relation to a project (Section 13(4)).

2.1.5 Australian Radiation Protection and Nuclear Safety Act 1998 (Cth)

The *Australian Radiation Protection and Nuclear Safety Act 1998* (Cth) establishes the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) to regulate Commonwealth activities that raise radiation protection or nuclear safety concerns. ARPANSA develops standards, codes or practice and guidelines for radiation protection and management. These issues are addressed in Chapter 12 and Appendix P.

2.1.6 Environment Protection and Biodiversity Conservation Act 1999 (Cth)

The *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) requires a person not to take an action that has or will have a significant impact on a Matter of National Environmental Significance (MNES) unless that action is approved. An action means any project, development, undertaking or any activity or series of activities (Section 523).

This project will not affect any of the following MNES (Chapter 2, Part 3):

- World Heritage properties,
- National Heritage places,
- wetlands of international importance,
- migratory species protected under international agreements,
- Commonwealth marine areas,
- the Great Barrier Reef Marine Park
- a water resource in relation to coal seam gas development.

The project (proposed action) was referred to the Commonwealth Department of the Environment (DotE) on 18 February 2015. On 16 March 2015 the Commonwealth Minister for the Environment determined that the action was a "controlled action" and required formal assessment and approval under the EPBC Act. Reasons included:

- the proposed action may affect listed threatened species and communities (sections 18 and 18A) including the listed vulnerable Black-Footed Rock-Wallaby (*Petrogale lateralis*) – MacDonnell Ranges Population, Greater Bilby (*Macrotis lagotis*) and Great Desert Skink (*Liopholis kintorei*)
- the proposed action is a nuclear action (sections 22 (1) (a) and (e)) due to the presence of certain minerals.

The bilateral agreement between the Commonwealth and the Northern Territory allows a single environmental impact statement process to be undertaken under the *Environmental Assessment Act* (NT) and the *Environmental Assessment Administrative Procedures* (NT) and for each jurisdiction (the Territory and the Commonwealth) to consider the results from such assessment and suggest conditions (in the case of the Territory) or impose conditions (in the case of the Commonwealth).

This EIS is submitted to the NT EPA and DoE for assessment in accordance with relevant legislation.

Listed threatened species and communities (sections 18 & 18A)

Listed threatened species and communities protected under the EPBC Act include species and communities that are considered to be extinct, extinct in the wild, critically endangered, endangered, vulnerable or conservation dependent. The impact and proposed mitigation measures proposed for the listed threatened species and communities are separately addressed in Chapter 9 of this EIS.

Nuclear Actions (sections 21 & 22A)

The impact of the project as a nuclear action is considered to impact the environment in a more holistic manner, and as such, has been addressed throughout the EIS. Refer to Chapters 9 and 12 for more information.

2.1.7 National Greenhouse and Energy Reporting Act 2007 (Cth)

Corporate entities, corporate groups or entities that have operational control of facilities are required to be registered (Section 12) and report emissions and energy use (Section 19) if such emissions or use exceeds statutory thresholds contained in the *National Greenhouse and Energy Reporting Act 2007* (Cth) (NGERA).

A facility emitting more than 25,000 tonnes of carbon dioxide equivalent, producing 100 terajoules of energy, or using more than 100 terajoules of energy annually is required to report under the NGERA (Section 13). A corporate group emitting more than 50,000 tonnes or carbon dioxide equivalent, producing 200 terajoules of energy, or using more than 200 terajoules of energy annually is required to report under the NGERA (Section 13).

2.1.8 Native Title Act 1993 (Cth)

The *Native Title Act 1993* (Cth) (NTA) provides for the recognition and protection of native title.

The grant of a mineral lease on an area where native title has been determined to exist (or where such area is subject to a registered native title claim) is a future act (Section 233) and will trigger the ‘right to negotiate’ process (Part 2, Division 3, Subdivision P).

The right to negotiate process requires good faith negotiations between the proponent, government party and native title party (together, the negotiation parties) with a view to obtaining the agreement of the native party to the doing of the future act or the doing of the future act subject to conditions (Section 31). In some circumstances, there may be more than one native title party.

If agreement is reached, the negotiation parties are will execute an agreement in accordance with Section 31(1)(b) of the NTA and the future act will be valid for the purposes of the NTA. A copy of such agreement is to be provided to the National Native Title Tribunal (NNTT) (Section 41A).

If more than 6 months have passed since notice of the future act was made under the NTA (Section 29), and no agreement has been reached following good faith negotiations, any party may apply to the NNTT for a determination that the future act may be done, done with conditions, or may not be done (Section 38). In the event that the NNTT is required to make such a determination, the NNTT is obliged to consider the criteria listed in Section 39 of the NTA, which include:

- The effect of the act on the native title party, their rights, their sites, land and waters, access to their lands and waters, way of life, culture, traditions and the development of the native title party
- The interests, opinions, and wishes of the native title party in relation to the management, use or control of land and waters affected by the future act
- The economic or other significance of the future act to the State / Territory or Australia
- The public interest in the doing of the act and
- Any other matter the NNTT considers relevant.

The NTA also provides for Indigenous Land Use Agreements (ILUA). An ILUA may provide for the non-application of the ‘right to negotiate’ process and include consents to the doing of future acts (or validate certain historical acts).NT An ILUA that has the effect of a contract between the parties and an ILUA that is registered in accordance with the NTA has the effect that all persons holding native title in relation to any area covered by the ILUA will be bound by the agreement (whether or not they are a party to the agreement) (Section 24EA).

The future act subdivision of the NTA also mandates certain processes of notification, consultation and or consideration of comments in relation to other types of future acts. Notification under Section 24MD of the NTA is likely to be relevant to the project in respect of infrastructure related mineral leases and access authorities.

A search of the National Native Title Tribunal Registers was undertaken on 12 May 2015. There is one native title determination covering part of the subject area, and two registered claimant applications.

2.2 Northern Territory legislation

2.2.1 Bushfires Act

The *Bushfires Act* relates to the prevention and suppression of bushfires. In the event Arafura requires controlled burning Arafura will seek a permit through Bushfires NT.

2.2.2 Control of Roads Act

The *Control of Roads Act* provides for the processes of opening and closing roads in the Northern Territory. Any public or gazetted roads that will be opened or closed as a result of construction or operations for the project will be subject to the provisions of this Act.

2.2.3 Dangerous Goods Act

The movement and handling of explosives and fuel gas is governed by the *Dangerous Goods Act* and the Dangerous Goods Regulations.

This legislation applies to the project as dangerous goods will be handled during construction and operation of the project. Arafura will obtain licences for storage or transportation of any dangerous goods, and project blasting permits if required.

2.2.4 Environmental Assessment Act and Environmental Assessment Administrative Procedures

In March 2008, the Proponent submitted a Notice of Intent to the former NT Department of Natural Resources, Environment and the Arts for consideration under the *Environmental Assessment Act* (EA Act). The then Minister decided that the project required assessment under the EA Act at the level of an Environmental Impact Statement (EIS).

Terms of Reference (TOR) for the EIS were issued by Northern Territory Environment Protection Authority (NT EPA) in May 2015. In summary, these detailed the scope and limitations of the proposed project in specific relation to regulatory context, existing environment, risk assessment and environmental management. This EIS addresses the TOR. This EIS is submitted to the NT EPA and DoE for assessment in accordance with relevant legislation and the requirements of the EA Act and the associated EA *Administrative Procedures*.

2.2.5 Heritage Act

The *Heritage Act* provides a system for the identification, assessment, protection and conservation of the Northern Territory's natural and cultural heritage. Under the *Heritage Act*, if any archaeological places or objects are to be disturbed, permission must be sought to carry out work on a heritage place or object. An application must be made with the consent of the owner of the place or object.

GHD contracted Archaeological & Heritage Management Solutions to undertake an impact assessment of any historic and cultural heritage items within the vicinity of the project (see Appendix U). Four archaeological surveys were conducted between 2006 and 2015 and have been referred to in preparation of the heritage section of the EIS. A Cultural Heritage Management Plan (CHMP) has been prepared and included in Appendix U.

A search of the NT Heritage Register was undertaken on 21 May 2015. Three places in the vicinity of the subject area are declared heritage places. Of these, Aileron Homestead and Ryan Well Historical Reserve are the closest, being located within 10 kilometres of the subject area.

Arafura intends to where necessary:

- Establish exclusion zones prior to commencement of the construction phase of the project
- Ensure any necessary archival recording and artefact collection takes place in accordance with legislation
- Consult with traditional owners (see Appendix U).

2.2.6 Liquor Act

The *Liquor Act* regulates the sale, provision and consumption of liquor. Any liquor provided at the project site will require licensing.

2.2.7 Mineral Royalty Act

The *Mineral Royalty Act* imposes royalties on minerals recovered in the Northern Territory and will apply to the project.

2.2.8 Mineral Titles Act and Mineral Titles Regulations

The *Mineral Titles Act* (MT Act) and the *Mineral Titles Regulations* establish a framework for granting and regulating mineral titles that authorise exploration for and extraction and processing of, minerals and extractive minerals.

Arafura requires a mineral lease for the proposed project under the MT Act. In February 2008, Arafura applied for a mineral lease under sections 41 and 66 of the MT Act, covering the Nolans Bore area and immediate surrounds (ML 26659; 1,404 hectares). Title will not be granted to ML 26659 until compliance with the aforementioned NTA processes have been completed.

Since 2008, the Nolans Bore mineral resource has approximately doubled and project requirements have altered, resulting in an expanded footprint to include a borefield, a downstream chemical processing operation and an accommodation village. As a result, additional mineral lease applications have been lodged with the NT Department of Mines and Energy (DME) to accommodate the expanded footprint. Land tenure details are described and illustrated in Chapter 1 of this EIS.

Arafura will report to the Minister about the activities conducted under the mineral lease and will require written consent if it wishes to disturb improvements on land in the title area or damage or otherwise disturb a Northern Territory or council road.

2.2.9 Mining Management Act and Mining Management Regulations

The *Mining Management Act* (MM Act) and the Mining Management Regulations regulate mining activities and the management of mining sites. The legislation is administered by the DME.

An operator of a mining site that proposes to undertake works that would cause “substantial disturbance” (as defined in the MM Act) requires an authorisation under the MM Act (Section 35). An application for an authorisation must include a Mining Management Plan (MMP) (Section 36). The MMP must describe the mining activities proposed and management systems to protect the environment, health and safety, details of ownership, plans for the mine workings and infrastructure, and a plan and costing of closure activities (Section 40).

Section 43 of the MM Act provides that an operator who carries out mining activities under an authorisation must provide a security to the Minister to secure compliance with the MM Act and cover the costs and expenses of preventing, minimising or rectifying environmental harm caused by mining activities.

A draft Environmental Management Plan (EMP) has been submitted as part of this EIS in Appendix X. An approved MMP will be required prior to commencement of proposed works if the project is approved.

A draft Rehabilitation, Decommissioning and Closure Plan has been prepared and is the first iteration of the plan for closure as required under the MM Act. It is important to note the plan will be reviewed and updated throughout the life of the project. Closure criteria have been developed as part of the Mine Rehabilitation Closure Plan and are set out in Chapter 18. A Certificate of Closure would be required based on achievement of closure criteria.

2.2.10 Northern Territory Aboriginal Sacred Sites Act

The *Northern Territory Aboriginal Sacred Sites Act* (Sacred Sites Act) protects sacred sites. It does this by establishing a procedure for the registration of sacred sites, and establishing a procedure for the avoidance and/or protection of sacred sites in the development and use of land.

Under the Sacred Sites Act, an Authority Certificate can be issued by the Aboriginal Areas Protection Authority (AAPA) that provides legal indemnity against possible prosecution in relation to damage to sacred sites resulting from the works or uses covered by the certificate, so long as any conditions imposed are followed. AAPA administers authority certificates in consultation with the relevant custodians under the Sacred Sites Act.

Arafura has undertaken sacred site clearances with AAPA, and authority certificates were issued in 2008 (C2008/205) and 2013 (C2013/205). Copies of the authority certificates are attached to the historic and cultural heritage report in Appendix U of the confidential report issued to the NT EPA.

2.2.11 Northern Territory Environment Protection Authority Act

The *Northern Territory Environment Protection Authority Act* establishes the Northern Territory Environment Protection Authority (NT EPA) as an independent regulatory authority with duties and functions under the *Waste Management* and *Pollution Control Act* and the EA Act.

2.2.12 Planning Act

The *Planning Act* (and the Planning Scheme made under that Act) does not apply to the conduct of mining activity under any mining interest (where the terms" mining activity" and "mining interest" have the same meaning as in the MM Act).

The land use controls under the *Planning Act* and the related Planning Scheme do not apply to unzoned land where activities are proposed to be undertaken. Exceptions, where consent is required, include a subdivision of land, a clearance of in excess of one hectare of native vegetation that is not otherwise controlled by legislation, or (in certain circumstances) the use or development of land within 500 metres of a designated road.

Proposals for logistical support infrastructure in Darwin and/or Alice Springs may fall under the *Planning Act* and will be subject to a separate approvals process.

2.2.13 Public and Environmental Health Act and Public and Environmental Health Regulations

The *Public and Environmental Health* Act (PEHA) and *Public and Environmental Health Regulations* (PEHR) are applicable to the project, in particular, the associated accommodation.

All sewage systems installed as part of mining operations must be approved by the Department of Health. Waste water treatment systems at the accommodation village may be subject to requirements under the PEHA and the PEHR.

Water bores outside a water control district are also required to be notified to the Department of Health.

The project will address these objectives and ensure the requirements of the applicable legislation are met. Additional information regarding human health and safety is detailed in Chapter 11 of this EIS.

2.2.14 Radiation Protection Act

Under the *Radiation Protection Act* (RPA), a person must not manufacture, sell, acquire, possess, use, store, transport, dispose of or otherwise deal with a radiation source other than in accordance with a licence authorising the person to do so.

Part 3 of the RPA stipulates that the operator of the mine site must monitor exposure to radiation and report to the CEO of ARPANSA and the Chief Health Officer.

Arafura will submit an application for a licence and will monitor the radiation, details of which are described in Chapter 12 of this EIS. The operation of the project will be regulated as a radiation practices under the RPA and under the requirements of the MM Act and *Work Health and Safety Act 2011* (refer Chapter 12).

2.2.15 Soil Conservation and Land Utilisation Act

The main purpose of this Act is to prevent soil erosion and conserve and reclaim the soil. To minimise impacts on soil erosion, an erosion and sediment control plan and mine closure plan have been prepared (see Appendix W) to meet the objectives of this Act.

2.2.16 Territory Parks and Wildlife Conservation Act

The *Territory Parks and Wildlife Conservation Act* (TPWC Act) protects *Territory* parks and reserves, animals and plants (including wildlife and protected wildlife).

The TPWC Act defines wildlife as that being in a park, reserve, sanctuary, wilderness zone or area of essential habitat, or is a vertebrate that is indigenous to Australia (other than fish), or is specifically prescribed as being protected by the TPWC Regulations. The TPWC Act prohibits the intentional killing of any terrestrial or marine vertebrate (with the exception of fish).

All threatened species are classed as protected wildlife. The TPWC Act precludes the taking of and interference with protected species of wildlife. The TPWC Act includes “Principles of Management”. These require that a threatened species be managed in a manner that “maintains or increases their population or the extent of their distribution at or to a sustainable level”. Threatened species are defined under the regulations as being species that are ‘extinct”, “critically endangered”, “endangered” and “vulnerable”.

The TPWC Act lists those species of plants and animals that are protected within the Northern Territory. Under the TPWC Act, permits will be required to take or interfere with protected plants or animals. This may apply if protected plants or animals are encountered during the project’s life. TPWC listed species and the associated impacts and mitigation measures are detailed in chapters 9 and 10 of this EIS and Appendix M and N.

2.2.17 Traffic Act

The *Traffic Act* requires that consent be obtained prior to the erection and operation of traffic control devices if required by the project, including during the construction phase.

2.2.18 Transport of Dangerous Goods by Road and Rail (National Uniform Legislation) Act & Regulation

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* (TDG Act) and the Transport of Dangerous Goods by Road and Rail (National Uniform Legislation) Regulations (TDG Regulations).

The TDG Act creates certain offences in relation to the movement of dangerous goods including:

- Failure to hold a dangerous goods driver’s licence
- Transporting goods too dangerous to be transported
- Failure to transport dangerous goods in a safe way.

The TDG Regulations also creates a number of specific offences, including:

- The sale or supply of dangerous goods in non-compliant packaging
- Labelling dangerous goods incorrectly
- Failure to segregate dangerous goods from food or food packaging.

This legislation applies to the project as dangerous goods will be handled and transported during construction and operation of the project. The appropriate licences will be acquired and the legislation adhered to.

2.2.19 Waste Management and Pollution Control Act & Waste Management and Pollution Control (Administration) Regulations

The *Waste Management and Pollution Control Act* (WMPCA) is the primary piece of environmental protection legislation in the Northern Territory. The WMPCA:

- imposes general environmental duties
- requires the licensing of certain activities
- establishes offences relating to the environment
- contains material enforcement, penalty and extension of liability provisions.

The WMPCA does not apply to a contaminant or waste resulting from a mining activity (as that term is defined in the MM Act) that is confined within the land on which the mining activity is being carried out.

This EIS addresses waste in Appendix X.

2.2.20 Water Act

The *Water Act 2004* provides for the investigation, allocation, use, control, protection, management and administration of surface and groundwater resources, as well as the administrative process for licensing these activities and related purposes.

Pursuant to Section 7 of the *Water Act*, mining activities (as defined by the MM Act) or another activity for a purpose ancillary to that mining activity, including the use of water as drinking water, are exempt from a number of provisions of the Act, including Parts 5 and 6 regarding surface water and ground water respectively.

2.2.21 Weeds Management Act

The *Weeds Management Act* (WM Act) aims to prevent the spread of weeds and to ensure that the management of weeds is an integral component of land management. This is to be conducted in accordance with the Northern Territory Weeds Management Strategy 1996-2005 (NRETA, date unknown) and any other current strategy adopted to control weeds in the Territory.

Noxious Weeds

Declared noxious weeds in the NT are plants proclaimed under the WM Act. The legislation requires that reasonable attempts be made to control or eradicate these species. Categories of noxious weeds include the following:

- Schedule Class A/C Weeds: These plants do not occur in the NT but pose a significant threat if they invade or if present, pose a serious threat. Reasonable effort must be made to eradicate these weeds
- Schedule Class B/C Weeds: These weeds often occur widely in the NT. They are capable of spreading further and should be prevented from doing so. Continuing control measures are required to prevent their spread. Reasonable attempts must be made to contain the growth and prevent the movement of these plants
- Schedule Class C Weeds: This category includes plants that pose an unacceptable risk of spreading in the Territory or to other parts of Australia if they were to be sold or traded in the NT and are a serious threat to another State or Territory of Australia. All schedule Class A and B weeds are considered to be Class C weeds.

The manager of the project site will be responsible for the management of weeds in accordance with the WM Act.

One noxious weed (*Tribulus terrestris*) was recorded within the study area. This plant will be controlled in accordance with the WM Act, as detailed in Chapter 9 and the Weed Management Plan contained in Appendix X of this EIS.

2.2.22 Work Health and Safety (National Uniform Legislation) Act 2011 & Work Health and Safety (National Uniform Legislation) Regulation 2011

The Work Health and Safety (National Uniform Legislation) Act 2011 (WHS Act) and Work Health and Safety (National Uniform Legislation) Regulations (WHS Regulations) regulates health and safety in the workplace.

The WHS Act requires the submission of a Risk Management Plan to NT WorkSafe covering the occupational health and safety aspects of the operation. The WHS Act also requires incident notification and compliance with health and safety duties.

Activities on the project site will be conducted in accordance with a Risk Management Plan approved and certified in accordance with Chapter 10 of the WHS Regulations.

If any facilities proposed as part of the project use above certain minimum quantities of specified chemicals the project may be considered to be a Major Hazard Facility and require licensing under Chapter 9 of the WHS Regulations.

The WHS Regulations apply to the use, handling and storage of hazardous chemicals at a workplace. In accordance with the WHS Regulations, Arafura will when necessary maintain a Hazardous Materials chemical register and use material safety data sheets.

2.3 Local government requirements

The project area is within the jurisdiction of the Central Desert Regional Council, covered by the Local Government Regional Management Plan for the Central Australian Region. The Local Government Regional Management Plan is a statutory instrument under part 3.1 of the *Local Government Act* (NT). Arafura will adhere to relevant Regional Council bylaws or requirements.

2.4 Policies and guidelines and standards

2.4.1 Northern Territory Environmental Protection Authority Assessment Guidelines

The NT EPA issues assessment guidelines to assist proponents in understanding and complying with the information requirements for the environmental impact assessment process. The guidelines relevant to the project are:

- Guidelines for the Preparation of an Economic and Social Impact Assessment
- Guideline for the Preparation of an Environmental Management Plan
- Environmental Assessment Guidelines on Acid and Metalliferous Drainage
- Guidelines on Conceptual Site Models
- Guidelines for Assessment of Impacts on Terrestrial Biodiversity
- Guidelines for Consultants Reporting on Environmental Issues
- Guidelines on Environmental Offsets and Associated Approval Conditions.

An Economic Impact Assessment (Appendix T), Social Impact Assessment (SIA) (Appendix S) and EMP (Appendix X) have all been prepared in accordance with the above guidelines and are included as part of this EIS.

2.4.2 Mine closure guidelines

Mine closure guidelines include the following:

- **Guidelines for Preparing Mine Closure Plans (Western Australia Department of Mines and Petroleum 2015)** - The DME published guidelines on 'Mine Closure and Completion' and 'Mine Rehabilitation' in November 2006. GHD understands that these documents have been withdrawn and are being updated.
- In the absence of NT guidelines, the Western Australia 'Guidelines for Preparing Mine Closure Plans, May 2015' are used.
- The content and scope of the Mine Rehabilitation, Closure Plan (MRCP) follows the requirements of the WA guidelines.
- **Rehabilitation and Closure Requirements for the Extractive Industry** – Provides an advisory note outlining the minimum rehabilitation and closure requirements for the extractive industry.
- **Code of Practice and Safety Guide -Radiation Protection and Radioactive Waste Management in Mining and Mineral Processing (ARPANSA 2005)** - Provides guidance on the safe management of radioactive materials during the operation and closure of mining and mineral processing activities.
- **Strategic Framework for Mine Closure (ANZMEC 2000)** - Presents a high level framework for the development of mine closure planning. The Nolans MRCP is within this framework.
- **Leading Practice Sustainable Development Program for the Mining Industry – Mine Closure and Completion (DRET, 2006)** - Provides guidance and Case Studies on sustainable approaches to mine closure across Australia.

- **Environmental Notes on Mining, (Western Australia Department of Mines and Petroleum updated September 2009)** - A Care and Maintenance Plan is required as part of the MRCP (see Appendix W). This is informed by the requirements and advice in this guidance note.
- **TEAM NT: Technologies for the Environmental Advancement of Mining in the Northern Territory Toolkit (NTMC and DMPM, 2004)** - Guidance and discussion of challenges specific to mining and mine closure in the Northern Territory.
- **Mine Close-out Objectives, Life of Mine Planning Objectives. NT DME 2006** - Sets out general requirements for setting closure objectives for mines in the Northern Territory. (refer Appendix W and X)

2.4.3 Other guidelines

Other guidelines that may be applicable to the project include:

- Department of Sustainability, Environment, Water, Population and Communities *Survey Guidelines*
- Department of the Environment *Significant Impact Guidelines*
- The Australian and New Zealand Environment Conservation Council (ANZECC) *Guidelines for fresh and marine water quality*
- Australian National Committee on Large Dams Incorporated (ANCOLD)
- International Atomic Energy Agency (IAEA) *Management of Radioactive Waste from the Mining and Milling of Ores Safety Guide WS-G-1.2*
- Mineral Council of Australia 2014 *Water Accounting Framework for the Minerals Industry*
- Northern Territory Department of Health 2014 Environmental Health Fact Sheet 700 *Requirements for Mining and Construction Projects*
- The Department of Land Resource Management (DLRM) *Guidelines and Field Methodology for Vegetation Survey and Mapping*
- Threat Abatement Plans, Recovery Plans and Survey Guidelines
- Department of Health *Guidelines for Preventing Mosquito Breeding Sites Associated with Mining Sites*
- Managing Acid and Metalliferous Drainage (DITR, 2007) and
- The Global Acid Rock Drainage Guide (INAP, 2011).

2.4.4 Australian Standards

The Australian Standards which are applicable to the project include:

- AS/NZS 4801:2001 Occupational health and safety management systems - Specification with guidance for use
- AS/NZS ISO 31000:2009 Risk Management
- AS/NZS 4360:2004 Risk Management
- AS/NZS ISO 31000:2009 Risk Management – Principles and Guidelines;
- AS2885 design, construction, testing, operations and maintenance of gas and petroleum pipelines that operate at pressures in excess of 1050kpa
- HB 436:2004 Risk Management Guidelines.

2.5 Environmental history

2.5.1 Proceedings

Arafura has no proceedings under a Commonwealth, State or Territory law for the protection of the environment or the conservation and sustainable use of natural resources. Similarly, there are no proceedings relating to the exploration activities to date (February 2016).

2.5.2 Association with the Mining Management Act

Arafura has MLs and ELs (as described in Chapter 1 of this EIS) under the MT Act which are associated with the MM Act.

2.5.3 Accreditations

Arafura has been operating in the Northern Territory since the late 1990s and has established and maintained good professional working relationships with NT regulators. Arafura has developed management system processes and protocols to guide and manage its exploration activities. These are not yet refined to a point where they comply with International Standard certified management systems. As Arafura transitions to the construction and operational phase of the project, it intends to design and roll out its final operating management system.

Arafura's activities and systems are based on the management of risk. Arafura has developed risk management, safety and environmental management plans, and all safety, environmental and community related incidents are routinely recorded. Meetings are convened on a regular basis with all key stakeholder groups to report on current and planned activities. Audits are also completed when operational activities occur at the Nolans site.

2.6 Ecologically sustainable development

As defined by the Commonwealth Government in 1990, Ecologically Sustainable Development (ESD) in Australia can be seen as:

> *'using, conserving and enhancing the community's resources so that ecological processes, on which life depends, are maintained, and the total quality of life, now and in the future, can be increased'*

The National Strategy for Ecologically Sustainable Development (Department of the Environment, 1992) was developed to encourage the sustainable use of Australia's natural resources for economic purposes whilst simultaneously increasing the range, variety and quality of the resource.

The guiding principles of ecologically sustainable development are:

- Precautionary principle: namely, that if there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation
- Inter-generational equity: namely, that the present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations
- Conservation of biological diversity and ecological integrity; namely, that conservation of biological diversity and ecological integrity should be a fundamental consideration
- Improved valuation, pricing and incentive mechanisms: namely, that environmental factors should be included in the valuation of assets and service.

The main challenge to ESD in relation to the proposal is the management of the renewable and non-renewable resources on which the mining industry depends. The main objectives listed in the strategy include:

- to ensure mine sites are rehabilitated to sound environmental and safety standards, and to a level at least consistent with the condition of surrounding land
- to provide appropriate community returns for using mineral resources and achieve better environmental protection and management in the mining sector
- to improve community consultation and information, improve performance in occupational health and safety and achieve social equity objectives.

As per the Arafura's 2014-2015 Sustainability Report (Arafura 2015):

- Arafura endeavours to minimise the production of waste products during its exploration activities. Contractors are required to recycle or dispose of waste products through licenced waste recyclers wherever possible.
- Water will be an integral requirement for the Nolans Project and Arafura has demonstrated a commitment to minimising impacts on groundwater resources in Central Australia. Extensive exploration has been undertaken aimed at locating a sustainable groundwater supply for the LOM.
- The project will leverage off Amadeus Natural Gas Pipeline lower cost and emissions-producing natural gas for power generation using high efficiency gas turbine generation. The Nolans processing circuit will provide 25-30% of the project's energy needs by recycling waste heat.
- Social sustainability is implemented in Arafura through Workplace Health and Safety (WHS), Human Capital Management, Stakeholder Engagement and an established Corporate Conduct. Arafura has adopted Corporate Governance charters, codes, policies and procedures including Continuous Disclosure, Code of Conduct, Trading in Company Securities, Whistleblower and Shareholder Communication. These are live documents available on the Arafura website www.arultd.com.
- Conservation of biological diversity and ecological integrity will be implemented throughout the project LOM through implementation of a biodiversity management plan and other operational controls (e.g. clearing permits etc.).

Implementation of ongoing sustainability practices assist in application and achievement of ESD guiding principles.

Rehabilitation, decommissioning and closure during and after mining operations have ceased are detailed in Chapter 18 of this EIS. The overriding intent of mine closure and rehabilitation is to return the land to, as close as is reasonably practical, its pre-disturbance condition.

The proposed closure and rehabilitation objectives for the Nolans Project will reflect the post-closure land uses and landforms agreed with stakeholders. As with the final land-uses, the closure objectives may be amended in later versions of the MRCP. Each objective will be applied, as relevant, to each domain of the project as detailed plans and protocols are devised. Where practicable and feasible, ESD will be considered during development and implementation of the MRCP.

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.

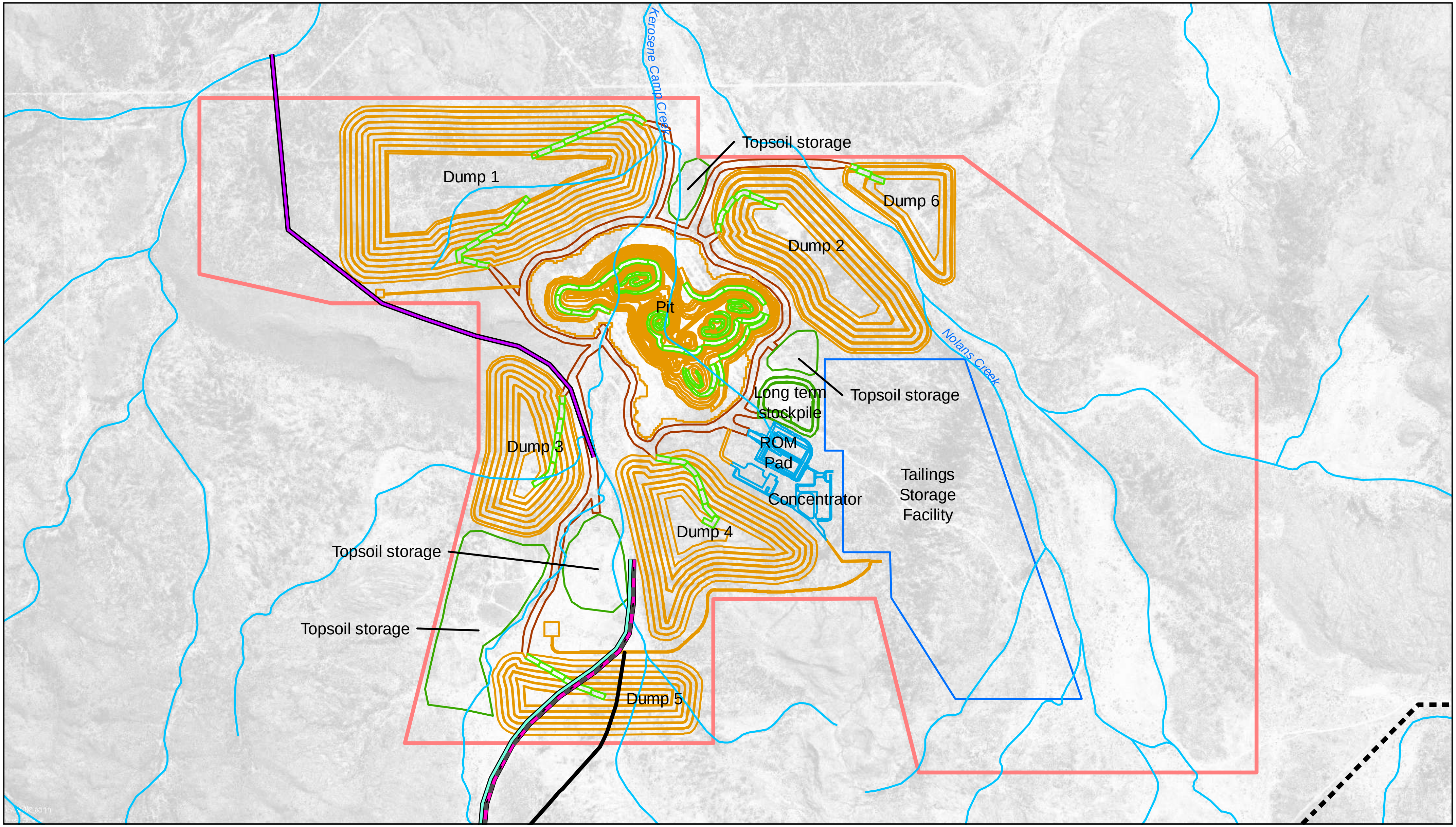
3.2.6 Logistics

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.



Arafura Resources Limited
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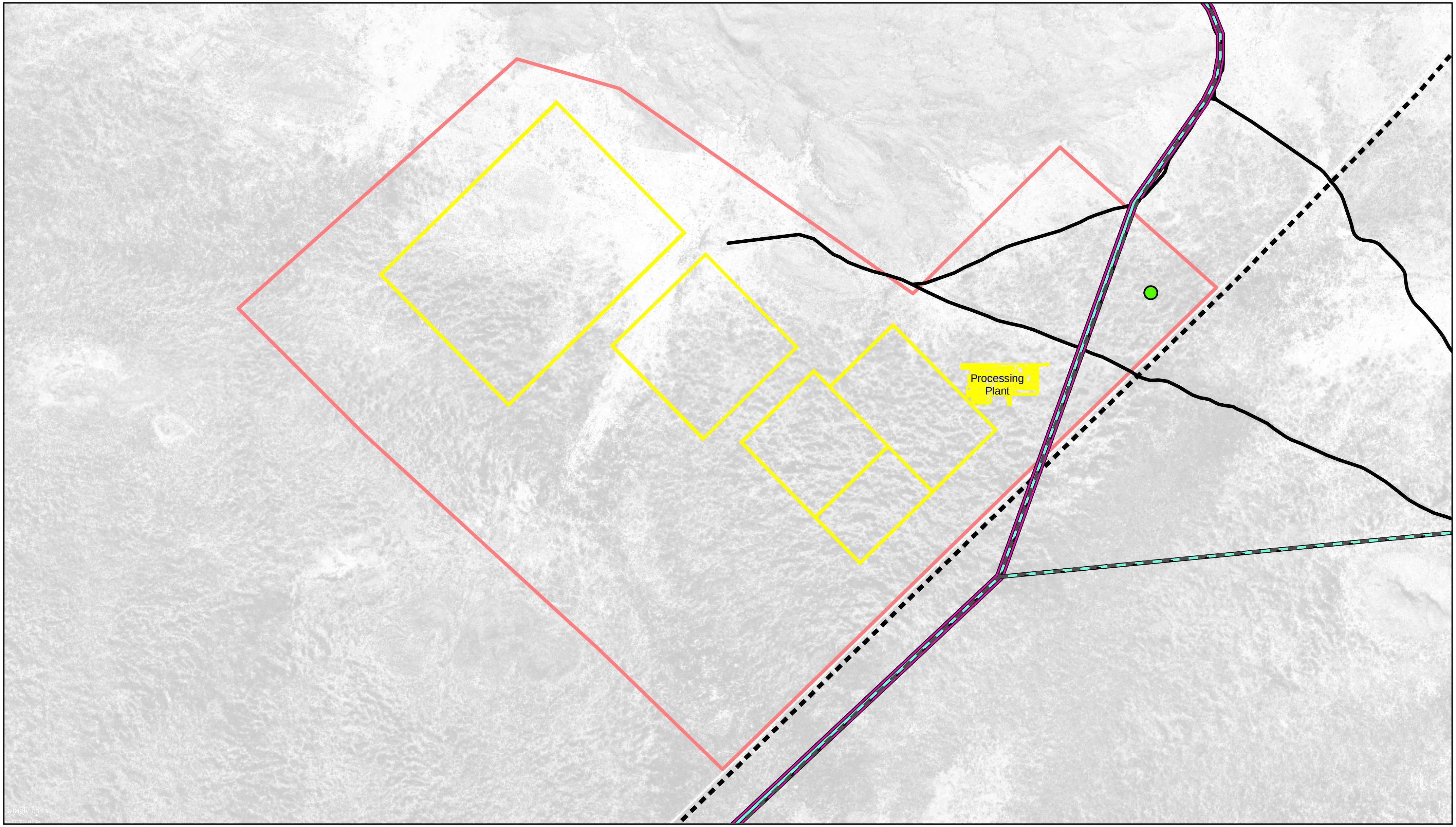
Mine site general arrangement

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



1:35,000 @ A4

0 250 500 750 1,000

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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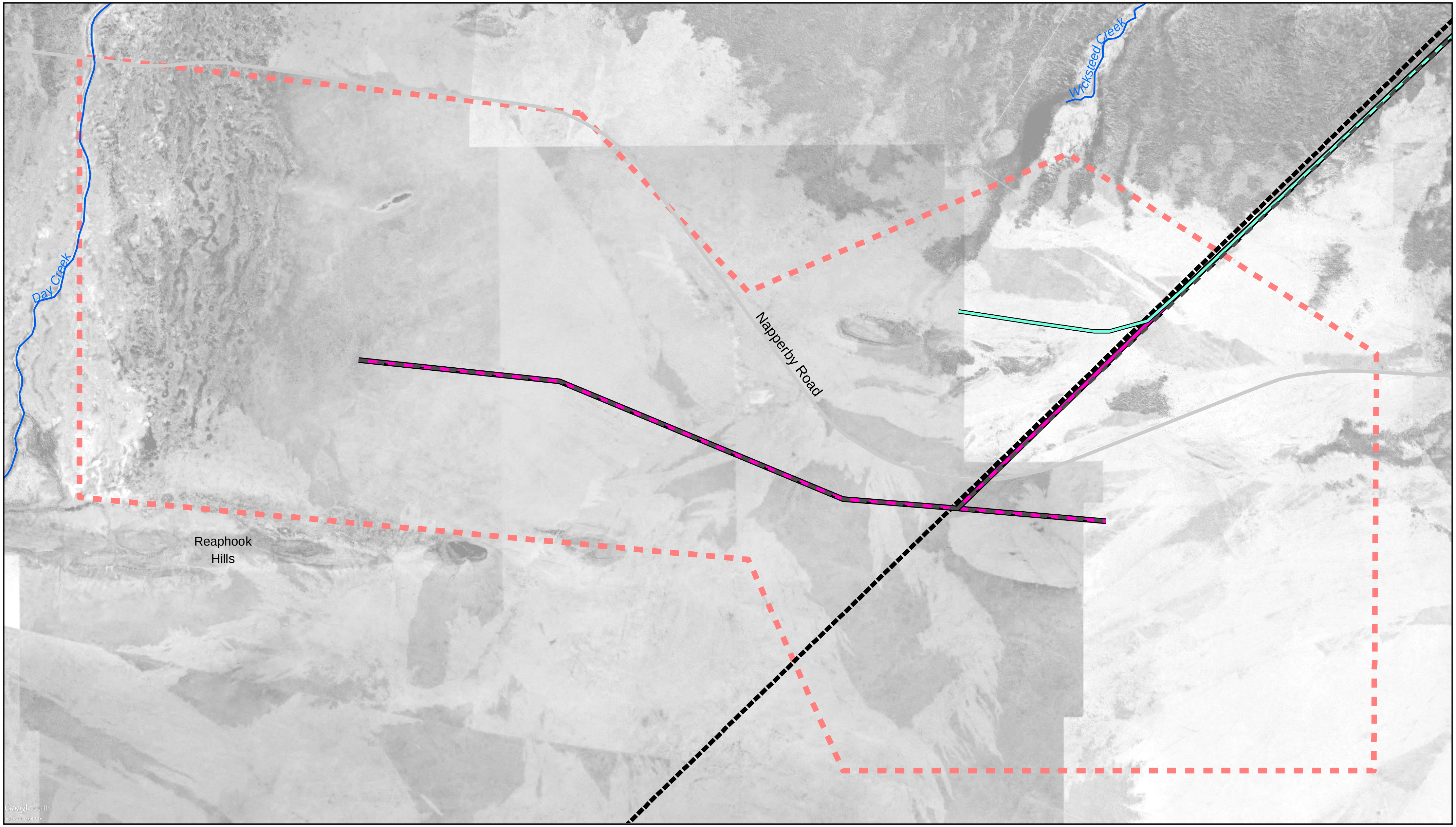
Processing site
general arrangement

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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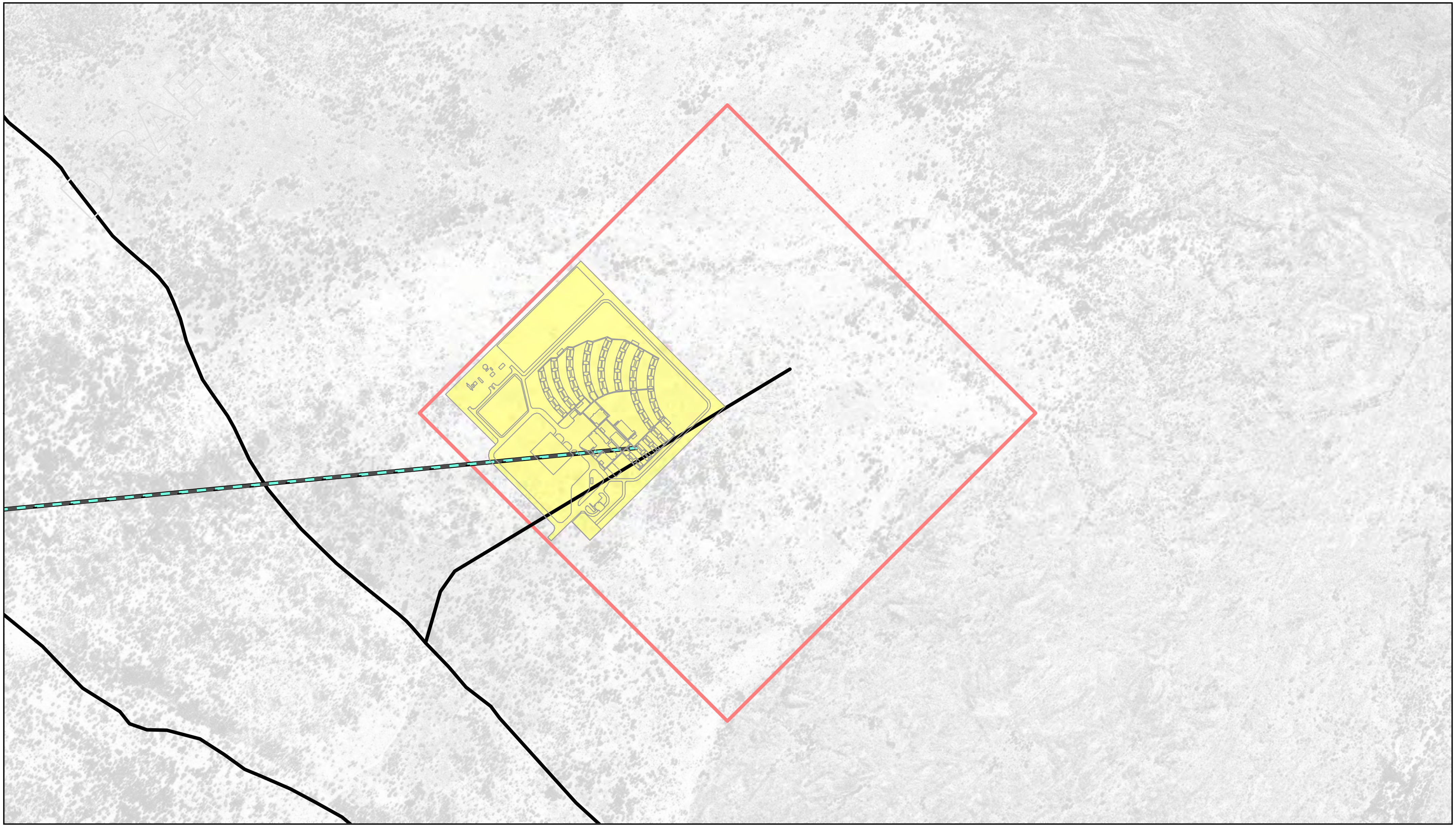
Borefield general arrangement

Figure 3-3

G:\43\22301\GIS\Maps\4322301_014_ProjectInfrastructureBorefield.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 Powerlines, Borefield Area (2015). Created by: CM



1:10,000 @ A4

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

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Date	18 Mar 2016

Accommodation village general arrangement

Figure 3-4

G:\43\22301\GIS\Maps\4322301_013_ProjectInfrastructureAccommodationVillage.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

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.

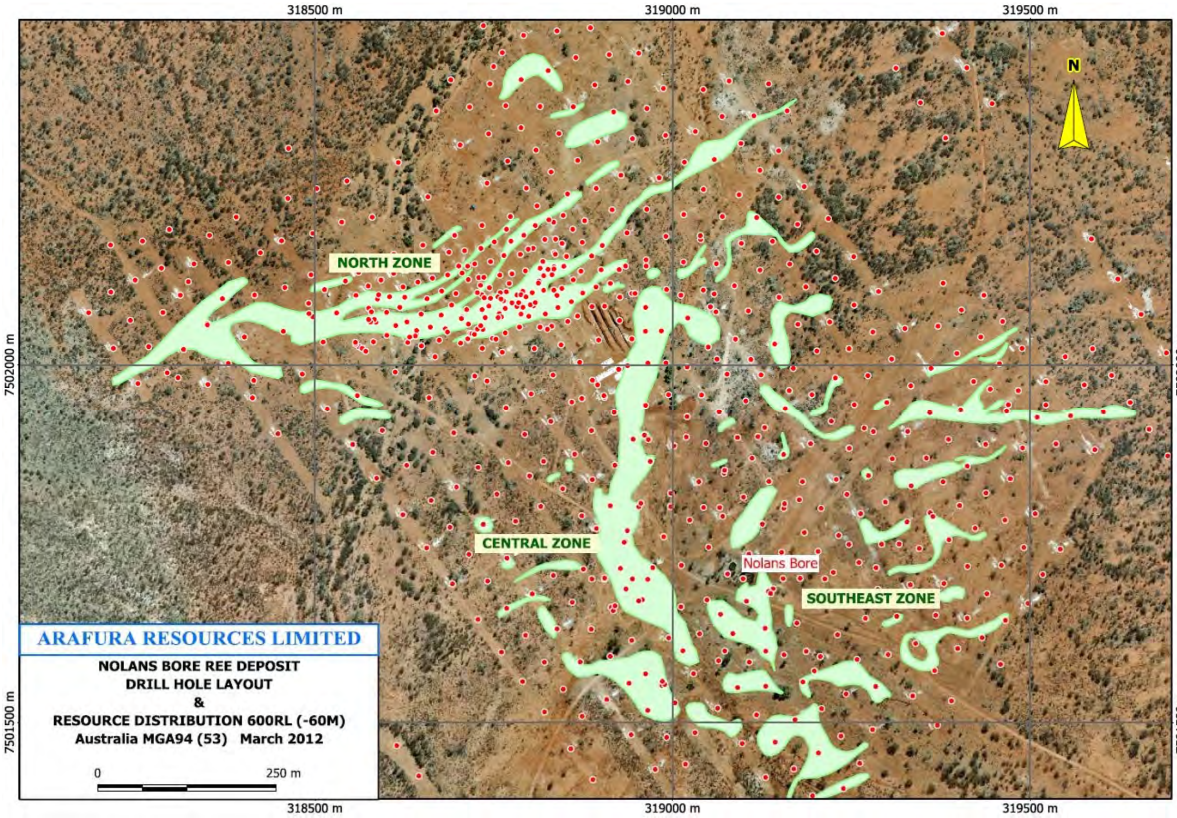


Figure 3-5 Distribution of drilling and mineral resources – plan view

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

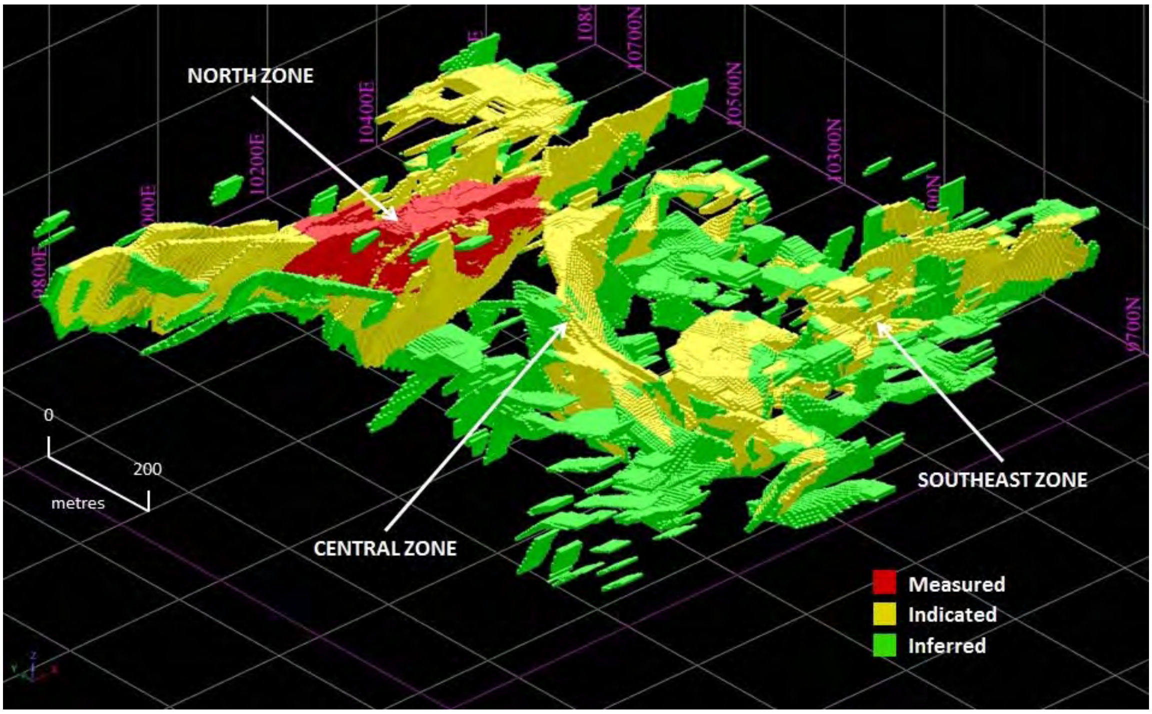


Figure 3-6 Distribution of mineral resource categories – oblique view

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%

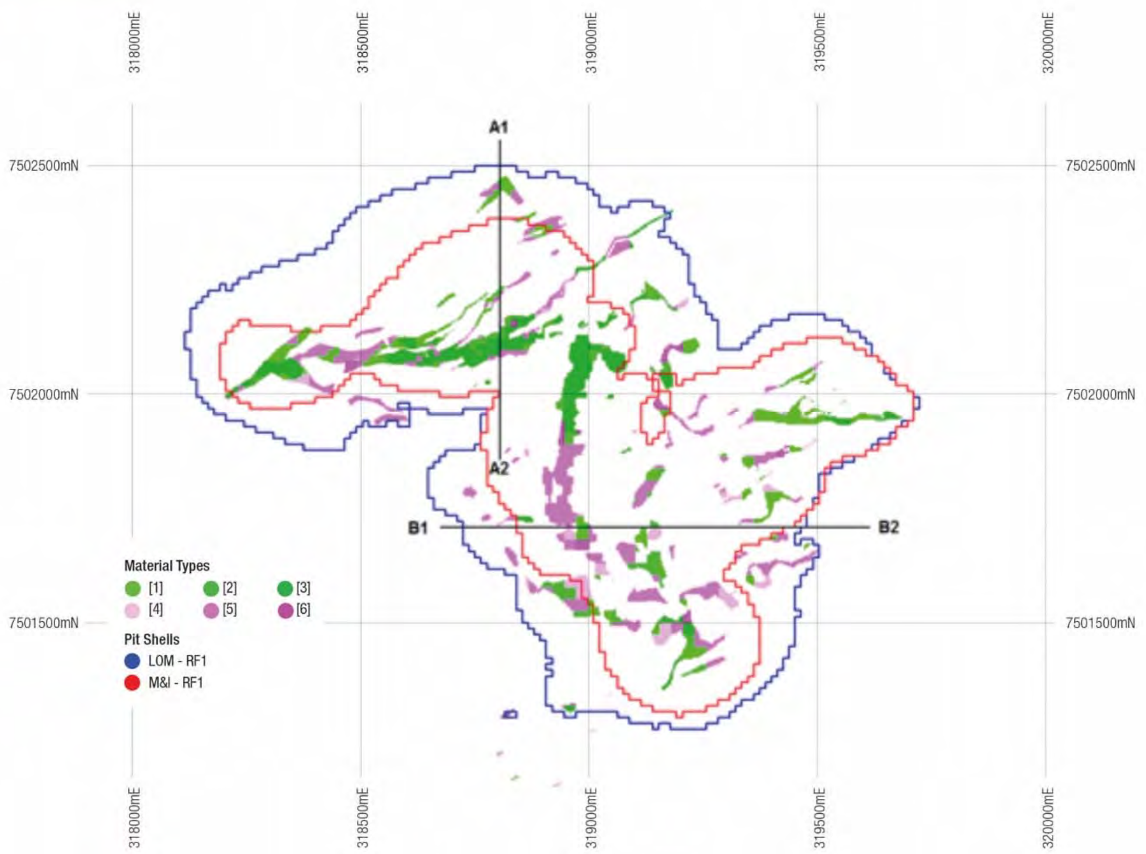
3.5.3 Future exploration

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.

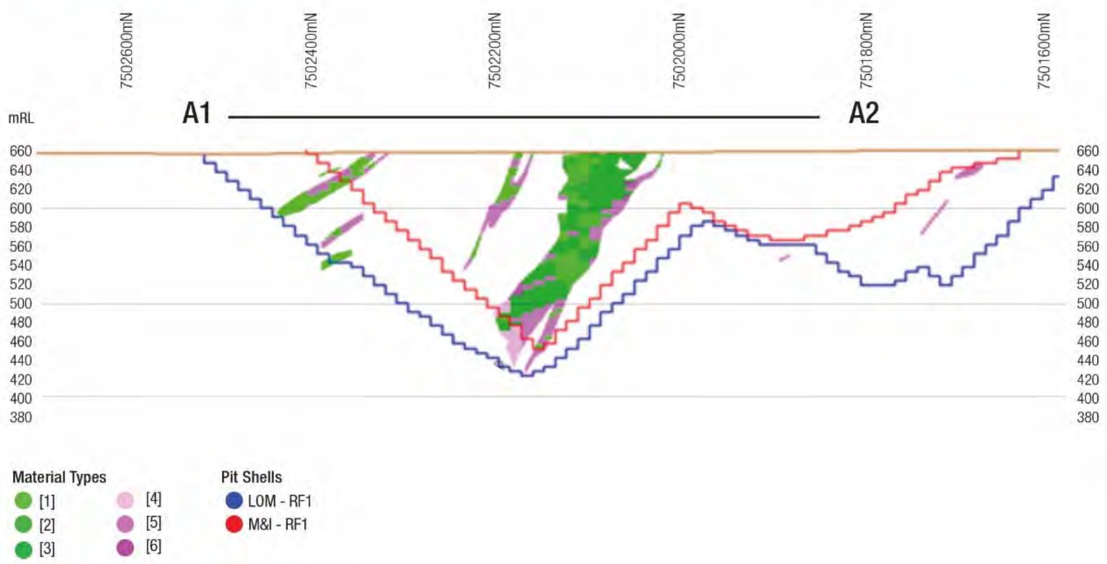
Arafura's exploration methodology involves flying airborne geophysical surveys to provide a focus for detailed on-ground geological, geochemical or biogeochemical investigation (as appropriate) in advance of drilling. Often, a target area fails to deliver encouraging results at an early stage of its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



Section View 318800mE (A1-A2)



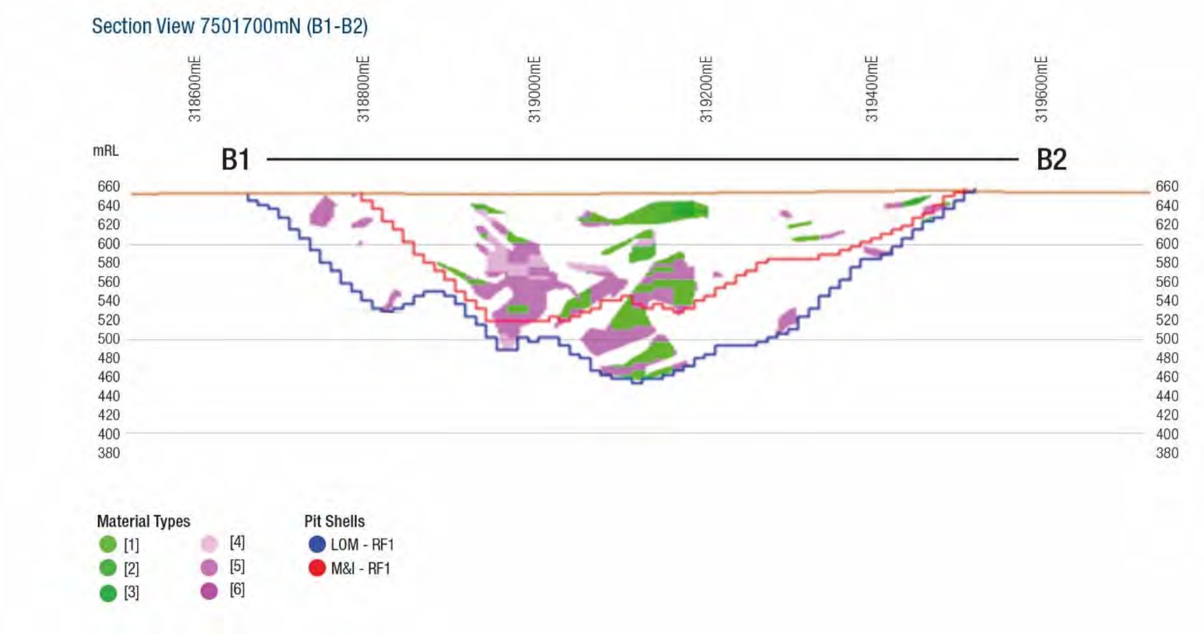


Figure 3-7 Distribution of material types

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.

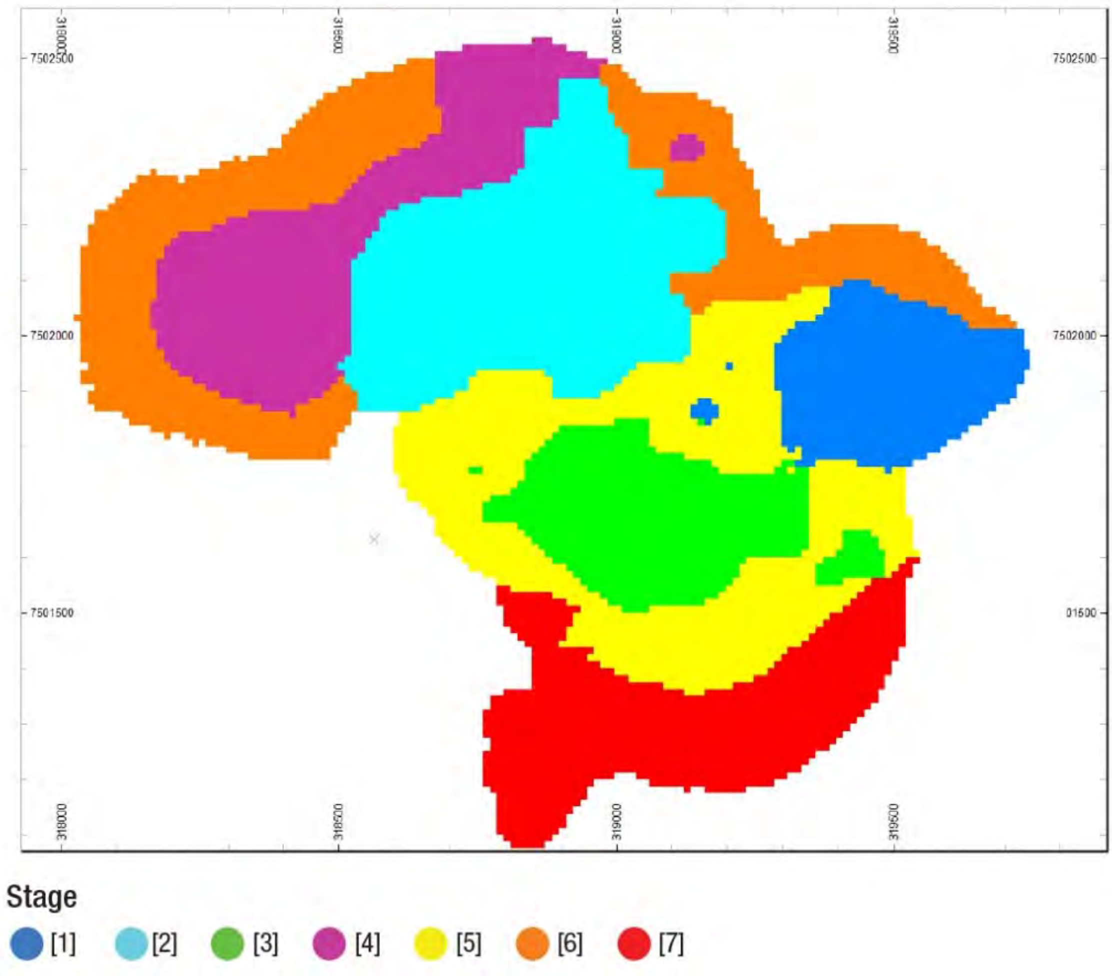


Figure 3-8 LOM pit stages

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.

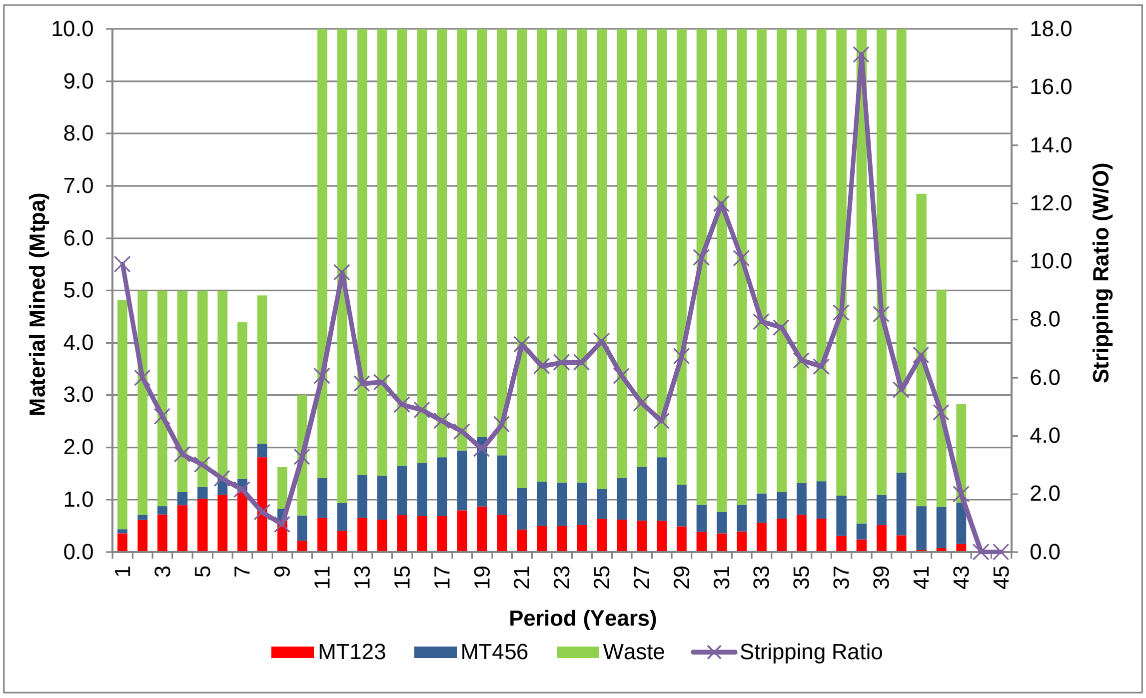


Figure 3-9 LOM production profile – material mined

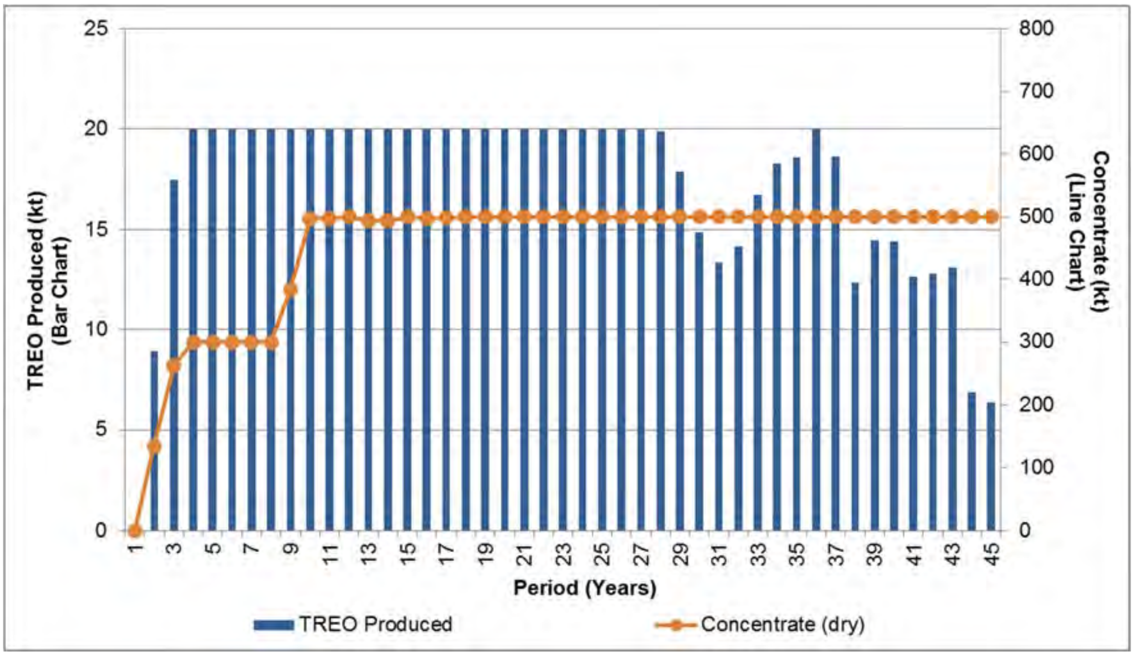


Figure 3-10 LOM production profile – concentrate and REO output

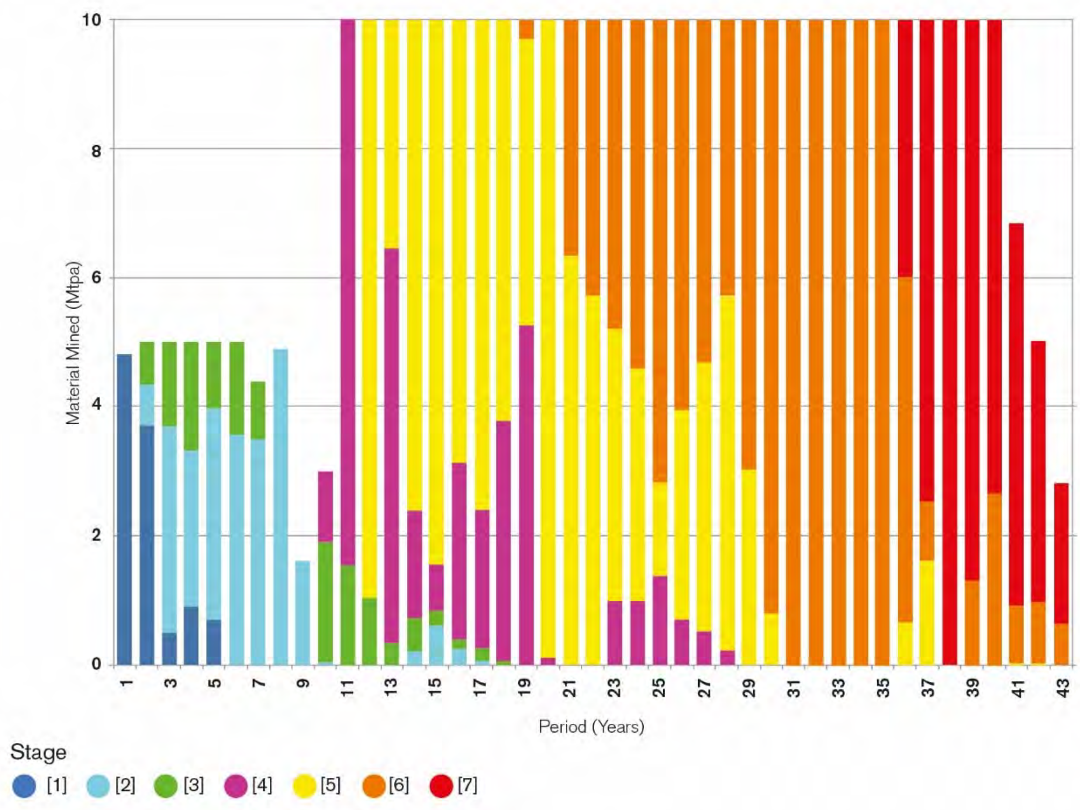


Figure 3-11 LOM production profile – pit stages

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.

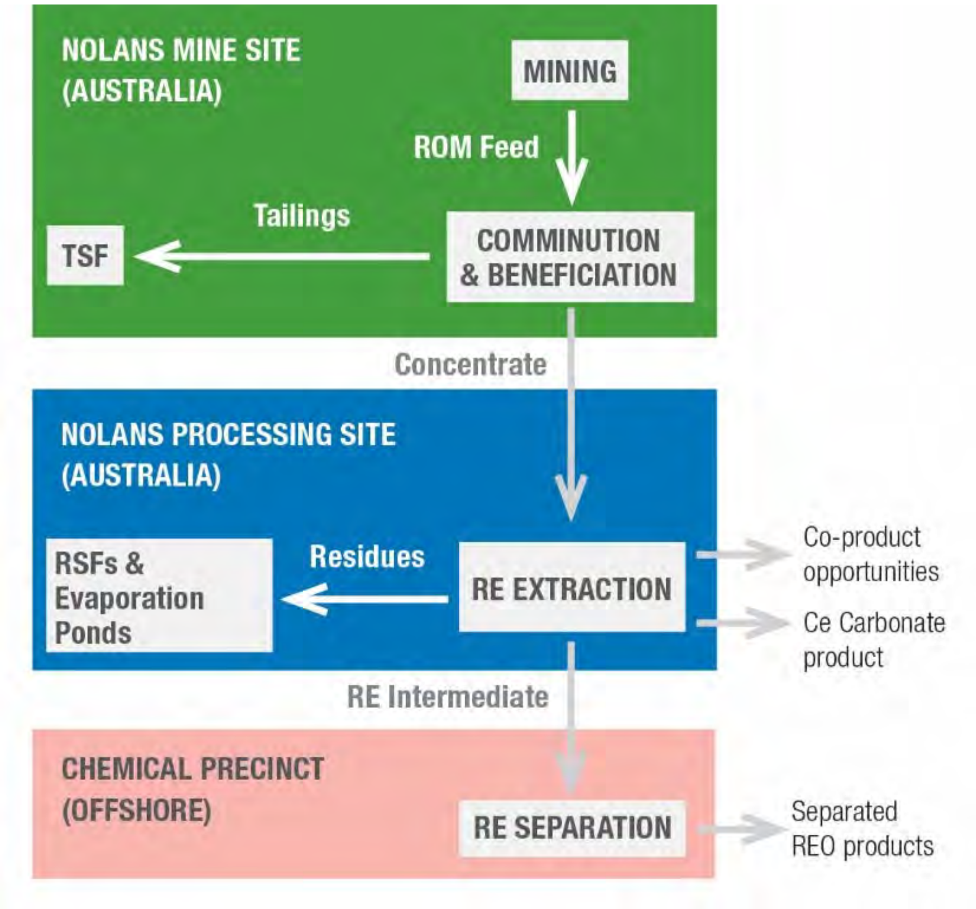


Figure 3-12 Process configuration

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.

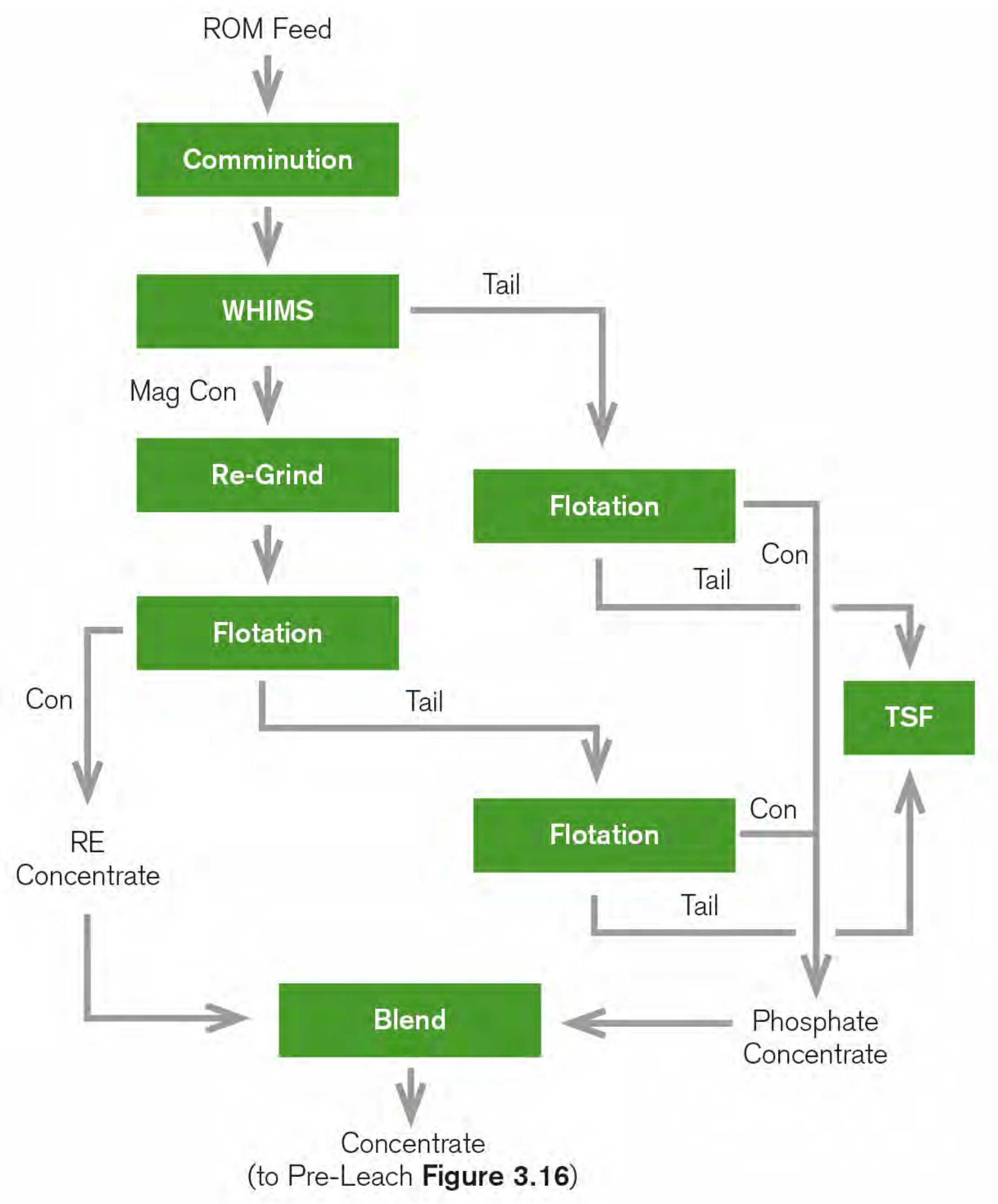


Figure 3-13 Concentrator circuit (Source: Arafura 2014)

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.

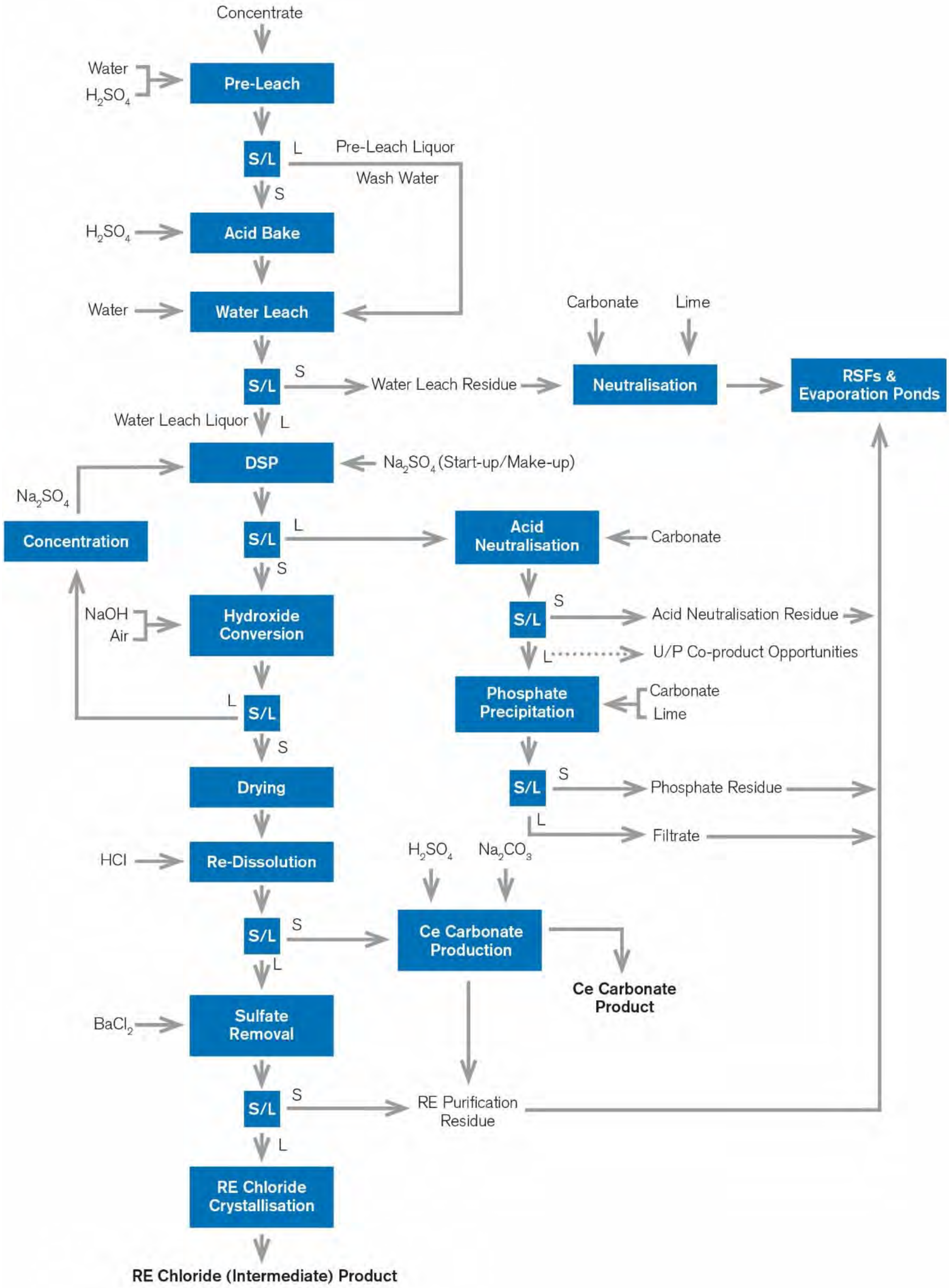


Figure 3-14 RE extraction circuit (Source: Arafura 2014)

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.

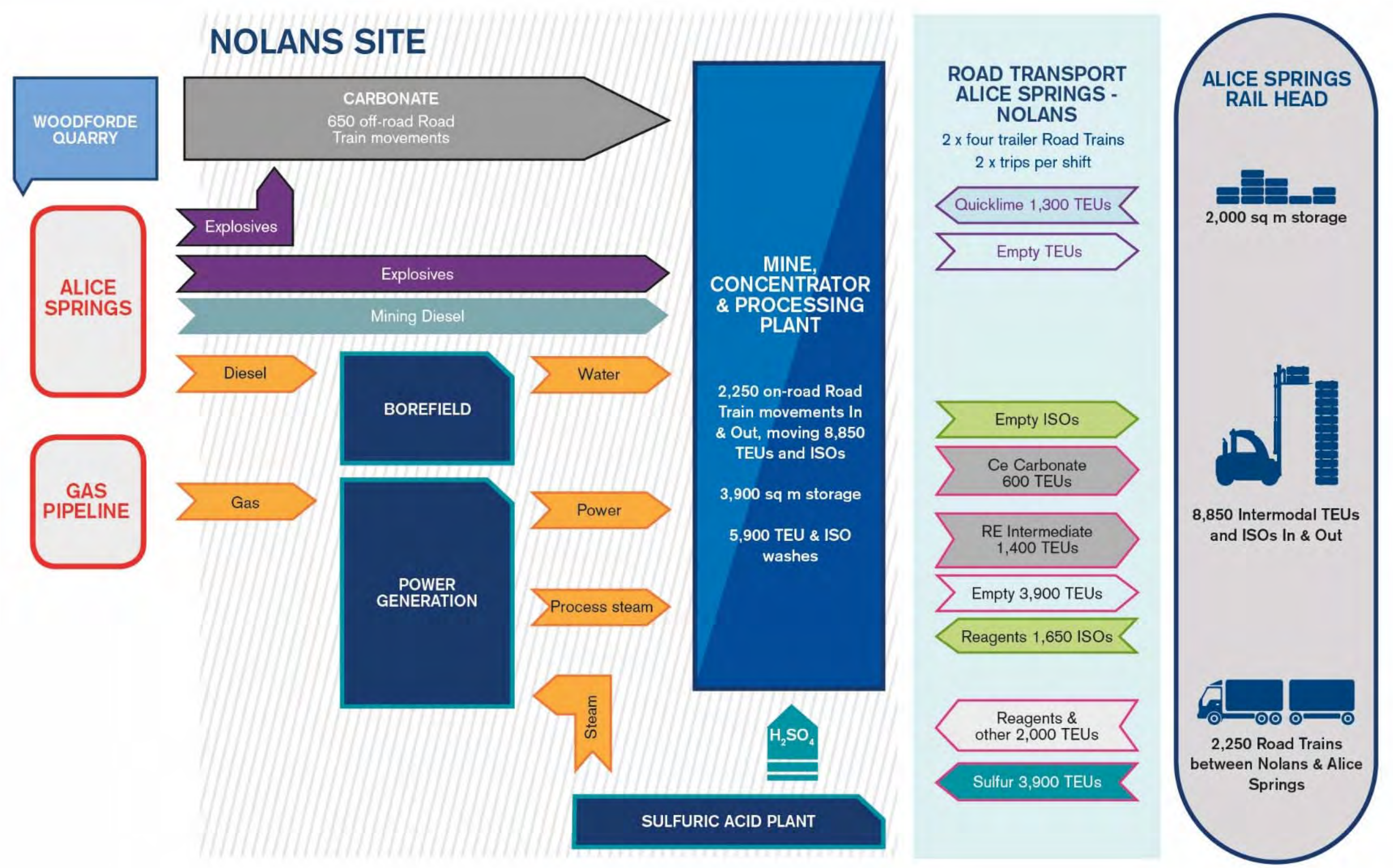


Figure 3-15 Nolans site - Alice Springs transportation (Source: Arafura 2014)

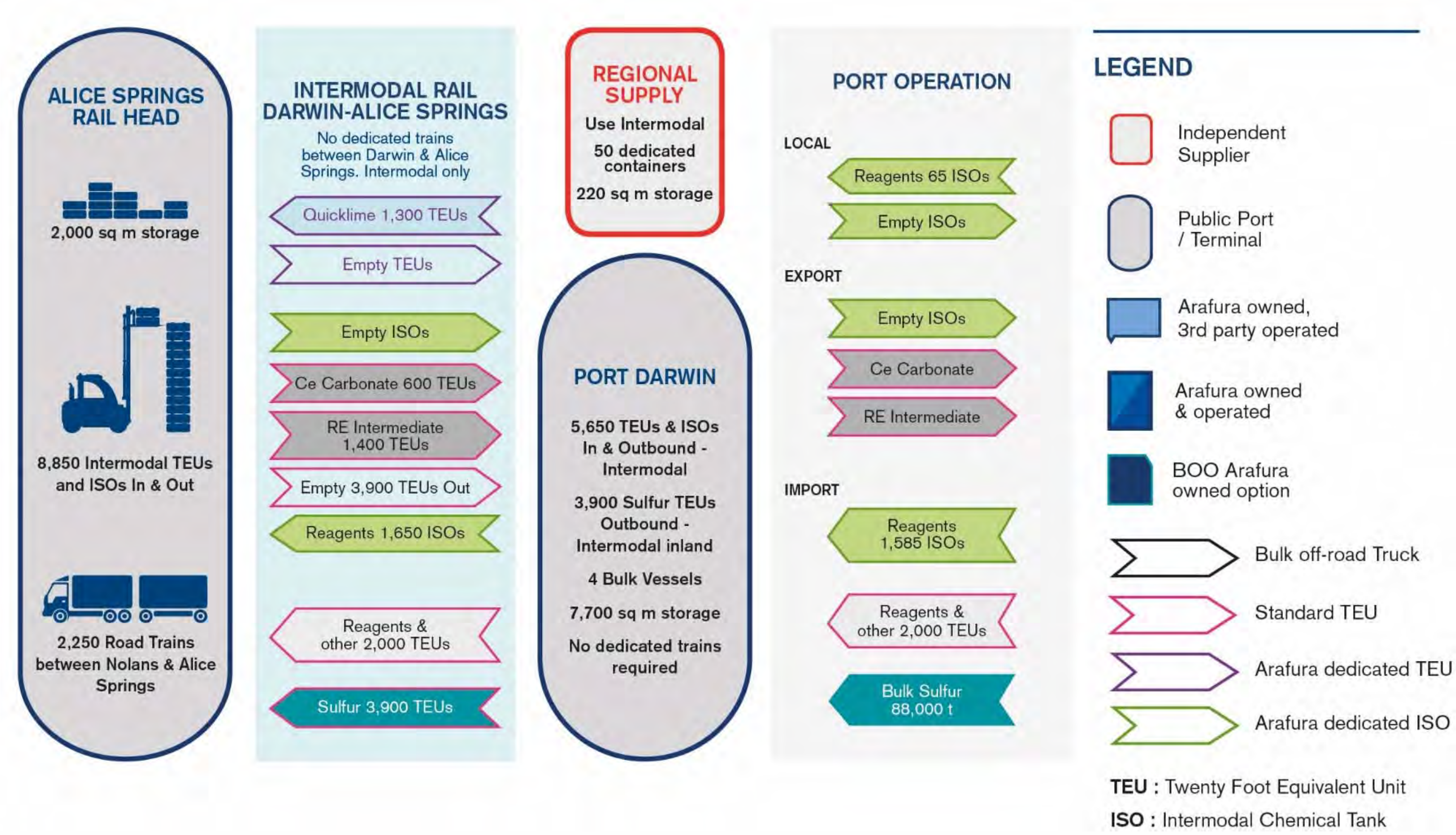


Figure 3-16 Alice Springs – Darwin transportation (Source: Arafura 2014)

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.

04

Project alternatives and cumulative impacts

4. Project alternatives and cumulative impacts

4.1 Introduction

This chapter discusses the alternatives considered during planning and scoping of the Nolans Project in Central Australia, and introduces potential cumulative impacts arising from compounding activities of multiple mining and processing operations, as well as aggregation and interaction of mining impacts with other past, current and future activities.

The TOR for the preparation of an environmental impact assessment issued by the NT EPA provided the following objectives in relation to alternative proposals:

> *Alternative proposals, which allow the objectives of the Project to be met, should be discussed … and the advantages and disadvantages of preferred options and alternatives detailed. The short, medium and long-term potential beneficial and adverse impacts of each of the options should be considered and associated risks should be detailed and analysed.*

Section 3.3 of the TOR provided the following environmental objectives in relation to cumulative impact:

> *An assessment of cumulative environmental impacts should be undertaken … to ensure that any potential environmental impacts are not considered in isolation.*

This chapter describes the project alternatives that have been considered by Arafura as part of the development process, and the potential cumulative impacts stemming from the effects of the Nolans Project on top of impacts that may arise from other significant mining or infrastructure projects within the local area. This includes impacts on community, environment and MNES, the duration of the potential impacts and potential mitigation measures.

4.2 Project history

The Nolans Project was initiated in 2005, and since then technical and commercial scoping and development has been ongoing in order to address the project's opportunities and constraints.

The Nolans Bore rare earths deposit comprises unique mineralogy that presents technical challenges in processing and recovery. The project's development timeframe has therefore been necessarily lengthy and has required a significant research and development phase. The benefit of this lengthy development timeframe is that Arafura has had the opportunity to gain significant insight into the project, the development options and appropriate outcomes for the owners, the stakeholders and the environment.

Various project development streams have been ongoing since project inception that focus on process and recovery including economics, process technical feasibility and treatment options, and marketable products. The planning and development phase has also had a focus on project optimisation, de-risking the project and mitigating the project's impacts, including impacts on the environment.

Accordingly, a range of project locations and processing configurations, project inputs and mitigation options have been considered and investigated.

The project alternatives considered since project inception include:

- Not proceeding with the project
- Location / configuration
- Processing alternatives
- Mining methodology
- Raw water supply
- Raw materials supply
- Carbonate material
- Power supply
- Accommodation
- Project supply, logistics and transportation
- Kerosene Camp Creek diversion
- Rehabilitation and closure.

4.3 Project Alternatives

4.3.1 Not proceeding with the project

Not proceeding with the project is an alternative in an economic environment dominated by falling commodity prices and increasing processing costs.

The Nolans Project has the potential to provide significant short and long term economic and social benefits to the Northern Territory and particularly to the Central Australian region including:

- Annual production and export of up to 43,000 tonnes of intermediate rare earths product (which represents a sizable supply alternative to Chinese production of this strategic material) and a source of production royalties and taxation payable to the Northern Territory and Australian governments
- Capital expenditure of about $850 million on construction of the mine, concentrator and processing plant, which includes nearly $145 million in the Territory and of that, about $70 million in Central Australia
- Operational expenditure of approximately $38 million in the Territory including about $18 million per annum in Central Australia, over the 40+ year life of the project
- 400-500 direct construction jobs
- 250-300 direct operations jobs
- Business opportunities to supply goods and services during construction and operations, with some coming from local suppliers in Alice Springs and other nearby communities
- Community benefits and royalties over the life of the project to local stakeholders.

These and other economic and social benefits are discussed in more detail in Chapter 15 and Appendix S and Appendix T.

4.3.2 Location / configuration

The Nolans Bore deposit contains moderate grades of rare earths and phosphate, and a relatively low grade of uranium. Given the mixed nature of the deposit, there are a range of challenges in economically processing the ore away from the general mine site.

Two options were investigated for an off-site processing location prior to Arafura deciding to locate most of the operation at the Nolans site.

Option 1 - Mineral concentrate transported from Nolans mine site to a Darwin processing plant

The initial project configuration included an open cut mining operation and concentrator, producing about 600,000 tpa of mineral concentrate which was then to be transported via a dedicated haul road, crossing the Stuart Highway, from the mine site concentrator to the Adelaide-Darwin railway line for loading and rail transport to Darwin. A large processing facility including a separation plant was to be built at Wickham Point in Darwin Harbour.

This configuration was eventually rejected based on logistical issues and environmental challenges which included:

- Water supply at the processing site could not be secured
- Land availability at Wickham Point was limited
- The size of evaporation ponds to manage water requirements and rainfall events in a cyclone region was excessive
- The logistics of transferring large volumes of reagents from the Darwin Port through an urban environment to Wickham Point were difficult
- Project power requirements could not be met
- Stakeholder resistance was anticipated, for a project near Darwin Harbour, processing a mineral concentrate containing rare earths and radioactive elements.

Option 2 - Mineral concentrate transported from Nolans mine site to China

The option to export up to 600,000 tpa of mineral concentrate to China for downstream processing was also considered early in the life of the project. However, it was rejected on the following grounds:

- The concentration of radionuclides in the mineral concentrate greatly exceeded the allowable limit of 0.05% defined in the relevant Australian export control regulations. This will make exportation difficult without onerous approvals and chain of custody controls.
- Uncertainty surrounding Chinese Government policy and potential constraints imposed by it on the marketing and commercial viability of rare earths.

Option 3 – Mineral concentrate transported from Nolans mine site to a Whyalla based processing plant

Option 3 considered an open cut mining operation and concentrator, producing 600,000 tpa of mineral concentrate, which was to be transported via a dedicated haul road, crossing the Stuart Highway from the mine site concentrator to the Adelaide-Darwin railway line for loading and rail transport to Whyalla in South Australia. A large processing facility including a separation plant was to be built on land owned by Arrium Steel near the steel works. This location and configuration was also eventually rejected based on a number of logistical and cost issues, and environmental challenges which included:

- Cumulative construction costs associated with the transport infrastructure (haul road, highway underpass and rail siding) linking the Nolans mine with the Adelaide-Darwin railway
- Water supply in Whyalla could not be secured without the construction of a large desalination plant
- The logistics of transferring large volumes of reagents via Port Adelaide and Spencer Gulf, in addition to transporting mineral concentrate from the Nolans mine to Whyalla
- Gas requirements could not be met without substantial pipeline upgrades
- Storage areas and stockpile requirements for processing by-products (e.g. gypsum) were problematic
- Environmental concerns around cumulative project impacts in the Upper Spencer Gulf. The Olympic Dam copper-uranium expansion was being considered at that time and a large desalination facility was being contemplated for that development. The Upper Spencer Gulf is a known breeding ground for the giant cuttlefish
- Cost of construction to build a processing plant to include what would have been Australia's largest chlor-alkali plant (for pre-leach processing and rare earth separation).

Option 4 - Mineral concentrate at Nolans mine site and a Nolans site-based processing plant

Following the discovery of a water supply suitable for the project southwest of the Nolans mine site in late-2012, work then focused on reconfiguring the project for a Central Australia operation. Two sub-options were considered:

- Option 4a – all project infrastructure at the mine site, separation offshore
- Option 4b – project infrastructure split into two parts, separation offshore

Option 4a

Initial project scoping located all project infrastructure at the mine site. After investigation, this configuration was modified to remove the final rare earth separation plant to an offshore location.

The final separation (refining) phase of rare earths recovery requires large quantities of hydrochloric acid and caustic soda. It was concluded that this part of the process should be completed nearer to sources of these reagents where plentiful supply is available as by-products of existing large-scale chemical operations. This aspect of the project was further investigated and two locations have been selected for final scoping and assessment, one in South Korea and one in the Gulf States region of the USA. This decision also removed the requirement to transport very large volumes of liquid reagents to the Nolans site from Darwin Port.

Whilst the project configuration investigation was occurring, environmental studies and community consultation work was ongoing. From these, stakeholder concerns were raised about the placement of the processing plant within the Ti Tree Basin catchment. Arafura did not conduct any hydrological studies to determine if the proposed processing plant would impact on the Ti Tree Basin catchment, but elected to investigate a modified split site configuration to address these perceptions and concerns.

Option 4b

This option considered splitting the site operations into two parts resulting in a mining operation and concentrator at the Nolans Bore site, and a processing facility about eight kilometres south of the mine site. This will place the processing plant in the Southern Basins water catchment, thus removing it from the Ti Tree Basin catchment. A suitable area was selected on shallow basement rock located near the Amadeus Basin – Darwin natural gas pipeline.

Mineral concentrate will be pumped to the processing plant via a bunded slurry pipeline running between the two sites. An access road will connect the two sites and a power and water corridor will follow the road alignment.

The decision to relocate and consolidate the processing plant back to the Nolans site in Central Australia has a number of clear, short and long-term economic benefits for the region and additionally has other logistical and environmental benefits. These include:

- Transport of large quantities of radioactive mineral concentrate (600,000 tpa) via road and rail through communities (e.g. Alice Springs) is eliminated
- All radioactive elements remain at the Nolans site following processing and removal into secure storage
- Reduced importation of reagents and transport requirements
- Increased opportunities for regionally based infrastructure to leverage off the project.

Option 4b is the option proposed in this EIS.

4.3.3 Processing alternatives

Test work and optimisation has been completed to determine the most efficient way to produce a mineral concentrate (i.e. beneficiation) from Nolans Bore. This research and development test work has been ongoing since 2005 and has been supported, in part, by Commonwealth grants and test work in Commonwealth laboratories including CSIRO and ANSTO. The initial comminution test work utilised multistage crushing and screening. This option has now been replaced with an alternative single stage crushing process and a grinding circuit. The most important advantage of this change in the comminution process has been a significant reduction in potential dust emissions, throughout the life of the mine.

Hydrometallurgical test work has been undertaken over the past eight years. These programs have employed a variety of leaching acids to deliver the most cost- and capital-efficient process option. Arafura has investigated a hydrochloric acid-based process, but from an economic and risk management perspective, the case for sufuric acid (i.e. sulfuric acid pre-leach – double sulfate precipitation, or SAPL-DSP) has outweighed the alternative process.

Arafura continues to investigate further process improvements. An alternative pre-leach reagent and purification process currently remains under active consideration, however the SAPL-DSP process is technically proven and financially viable' and is the foundation of the project described in this EIS.

Additionally, Arafura has and will continue to investigate the recovery of all potential products from the Nolans Project, including rare earths, phosphate and uranium. The current SAPL-DSP process is focused only on the commercial recovery of rare earths, however if the economics of phosphate or uranium improves sufficiently; or should a commercial market for thorium emerge, consideration may be given to modifying the process to recover and commercialise some or all of these co-products, or to investigating the viability of co-product recovery from tailings or process residues.

4.3.4 Mining methodology

The Nolans Bore resource is near surface and extensive. It occurs as wide, steeply dipping interconnected veins and zones, and as a consequence, is most efficiently mined using open pit truck and haul methods. The resource is delineated only to a depth of 215 metres below surface however, and deeper drilling demonstrates that mineralisation continues down beneath this level.

Consequently, underground mining may be contemplated in the future, following the open pit mining of the upper section of the orebody; but this is unlikely within the current life of mine plan. The current mining schedule (see Chapter 3) is aimed at optimising recovery of the orebody using the open pit mining methodology.

4.3.5 Raw water supply

In 2010, a source for a sustainable water supply for the mine and concentrator were investigated based on processing off site. Initial investigations focussed on locating a groundwater supply from the Ti Tree Basin, a 25-30 kilometres north and northeast of the mine site. These investigations were successful and established the presence of a suitable groundwater supply for the mine and concentrator requirements, of up to two gigalitres per annum.

In the latter part of 2012 Arafura began scoping a shift of the processing plant from Whyalla back to the Nolans site. As part of this process, and taking account of the likely increased raw water requirements of an expanded operation at Nolans, it became apparent that the concerns of competing users of the Ti Tree Basin and other stakeholders will need to be considered. Consequently, the company undertook a wider regional search for alternative sources of groundwater.

In 2012 alternative studies into securing a larger groundwater supply were initiated, in order to facilitate a shifting of the processing plant back to the Nolans site. The Ti Tree Basin would not be suitable for this process, due to competing users of this resource and stakeholder concerns.

In December 2012, Arafura commenced a water exploration program about 35 kilometres southwest of the mine site. This initial exploration was successful and a follow-up investigation program was completed in early 2013. This program confirmed the presence of an extensive groundwater system of aquifers, and was a key determinant in the company's decision to relocate the processing plant to the Nolans site.

Subsequent investigation and modelling have now confirmed this alternative water supply can sustain the Nolans Project well beyond the present life of mine, whilst also providing water for pastoral usage on a substantial area of Aileron Station which previously was unproductive. Details of the hydrogeological investigation work is provided in Appendix K.

Studies have also been completed to minimise raw water requirements. The production of rare earths is a water intensive process, requiring a number of washing phases for purification. Since the initial process design and test work was completed for the project however, the raw water requirement has been reduced by about 40% from 6 GL to 4.2 GL per annum.

Further optimisation is occurring, with aim of further reducing raw water supply requirements. Groundwater from the mining operation, packaged sewerage treatment plants and tailings return are intended to be recycled and reused throughout the project. A packaged water treatment plant will be incorporated into the processing plant to provide potable water for personnel and a treated supply for critical cleaning aspects of the rare earths processing. Process water that can no longer be recycled will be disposed via the TSF, RSFs or evaporation ponds.

4.3.6 Raw materials supply

The project has a range of raw material requirements for construction and operations. It is intended that the bulk of the raw materials, which includes rock, gravel, sand, topsoil and carbonate material, will be sourced either from within or near the Nolans site.

Rock will be selected during the initial pre-strip of the pit for use in various aspects of construction. Care will be taken to ensure this material is benign in terms of its chemical composition and radionuclide concentrations.

Gravel material will be sourced from an old road construction quarry on the Stuart Highway about 25 kilometres from the processing plant, or from a local source on Aileron Station about 12 kilometres from the plant. Prior to this occurring the necessary regulatory approvals will be sought. Other gravel for cement manufacture will be transported to site from quarries near Alice Springs.

Sand also required for cement making will be mined from that part of the Kerosene Camp Creek that will be mined as part of the open pit. Any additional sand requirements will be sourced locally but appropriate approvals will be sought prior to this occurring.

Topsoil will be removed as construction progresses, and will be stored in designated areas around the operation to ensure adequate quantities are available for use in rehabilitation. It is intended that topsoil removal will be staged as much as is practicable and reused progressively to ensure the viability of the soil is maintained.

4.3.7 Carbonate material

Carbonate material is required in the processing operation to maintain pH control. Arafura has investigated two alternatives for providing the required volumes needed for the project.

Option 1 considers transporting processing reagent requirements for pH control (lime) to the Nolans site from external suppliers (30,000 tpa). This would require additional rail transport and road transport for the life of the mine, on the Stuart Highway.

Option 2 considers site-based and nearby supplies of suitable carbonate material. The preferred strategy is to initially mine known calcrete occurrences at the mine site. These areas will eventually be buried by WRDs.

In addition to these modest resources, a large mapped occurrence of marble is located on Pine Hill Station that adjoins Aileron Station along its north western boundary. Initial test work on this material indicates it may be suitable for acid neutralisation, but further work is required to verify this. Arafura intends to complete an exploration program over the area to confirm sufficient marble is present to support the life of mine requirements of the project.

Should process test work and exploration prove successful, Arafura will seek a separate mining and environmental approval for a small quarrying operation of about 125,000 tpa. This would include the construction of an internal project haul road connecting the quarry with the processing plant (Figure 4-1). This small quarrying operation would provide further economic and social opportunity in the local region, but has not been factored into any of the studies presented in this EIS.

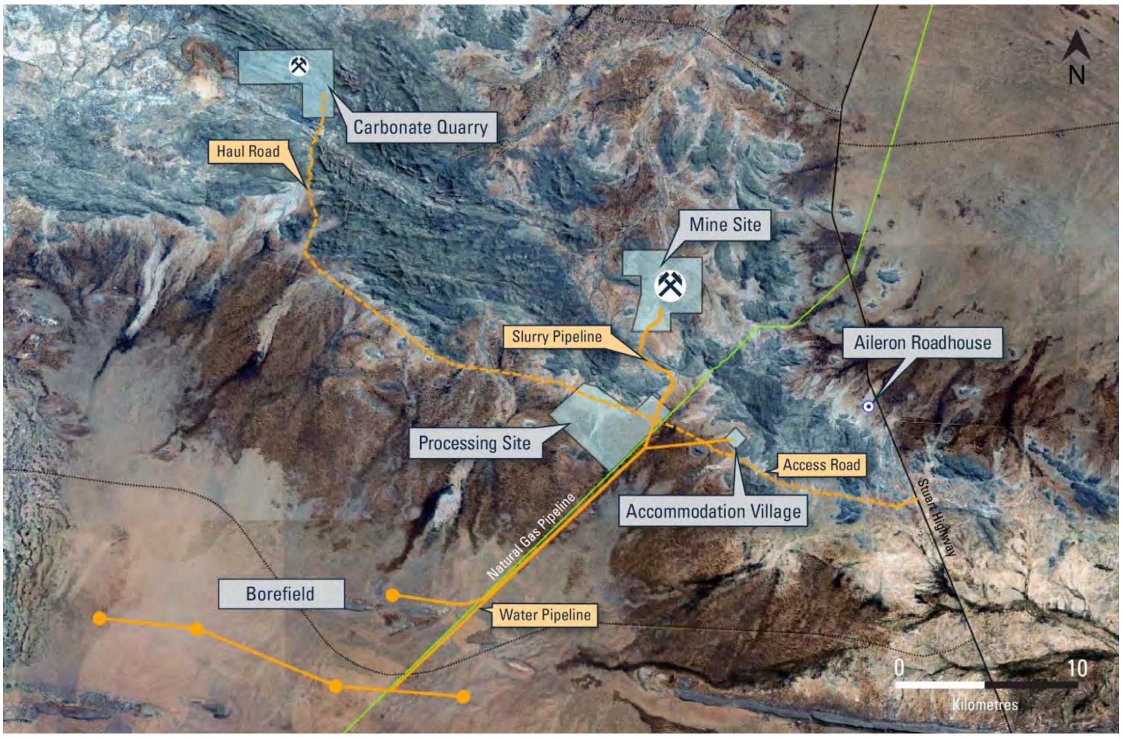


Figure 4-1 Nolans Site Layout, including the Woodforde Carbonate Project (source Arafura 2014)

4.3.8 Power supply

The inclusion of sulfuric acid plant within processing facility will also enable the project to recycle heat energy created from the exothermic reaction when producing sulfuric acid to be used to produce steam for turbines to generate about 6 MW of power. This recycling will enable 6 MW of gas fired generation to be turned off for long periods except when the acid plant is shut down for maintenance or repair, thus providing cost savings and reducing project emissions.

Additionally, Arafura is engaging with a number of power providers to investigate the potential for a regional power station, to not only service the project's requirements, but also the potential needs of local communities and horticultural developments in the Ti Tree Basin.

4.3.9 Accommodation

Two options for providing accommodation to employees have been investigated for the project.

Option 1 considered constructing the project's accommodation needs in close proximity to the Aileron Roadhouse. This was possible when the project's onsite scope was limited to a mine and concentrator, and a smaller estimated workforce of about 150. This would have provided significant growth for facilities at the roadhouse.

Option 2 followed reconfiguration of the project to incorporate a processing plant. It was determined that the placement of an accommodation village near the roadhouse to cater for a much larger workforce (250-300 during operations) would place too significant an impact on the operation and character of this iconic location. Locating a substantially larger village near the roadhouse would also increase the likelihood of interactions between the project workforce and local and passing trade, potentially leading to social tension and related issues.

The project's accommodation village has subsequently been relocated to a site four kilometres southeast of the processing plant. Additional temporary construction accommodation may be required during construction of the project but this will be removed as soon as practicable following completion of construction.

The roadhouse is only 20 kilometres by road from the project. To ensure economic benefits are realised locally, it is intended that visitors, shutdown workers, etc. will still be accommodated at the roadhouse facilities, to reduce the need for ongoing additional accommodation at the project.

4.3.10 Workforce transportation

Options to transport both the construction and operational workforce to the Nolans site from Alice Springs have been investigated.

Option 1 considered a fly-in fly-out operation directly to the Nolans site but this was ruled out because of cost, and because the option did not take advantage of the excellent regional transport infrastructure in Alice Springs.

Option 2 is the current proposal considered within this EIS. The construction and operational workforce will be bused in and out of Alice Springs to the site. Traffic volumes on the section of Stuart Highway between Nolans and Alice Springs are relatively low and the incremental additional traffic resulting from this option is unlikely to have an impact on other highway users or highway safety. Safety concerns with the use of private vehicles to and from site was another contributing factor in reaching this decision.

Consideration may be given to upgrading the Aileron Station airstrip to deal with emergency response situations.

4.3.11 Project supply logistics and transportation

Options have been investigated to provide logistical support and supply transport to the project.

Option 1 intended that a rail siding and logistics handling area would be constructed either 65 kilometres east of the project or just north of the Plenty Highway / Adelaide-Darwin rail intersection. Both of these options were discarded based on construction costs and the operational requirements of these types of facilities. There would also be additional short and long term environmental impacts from the construction and operation of this handling area.

Option 2 is the preferred alternative. This considers using existing logistical facilities and transport operators based in Alice Springs. The incremental impact of using the Stuart Highway as the main supply access to the project is low. This option will also result in the better use of existing local facilities, economic opportunity for local business, and local employment opportunities throughout the life of the mine.

4.3.12 Kerosene Camp Creek diversion

The existing course of the ephemeral Kerosene Camp Creek must be diverted as it intersects the planned open pit. This creek has a catchment of about 26 km^2 upstream of the pit and it is planned to divert the creek early in the establishment of the mining operation. Seven options for this creek have been considered, with four involving realignment. They are:

- Option A. Realign the creek bypass upstream of the pit to the west of the pit perimeter between the open pit and a natural hill at the western end of the pit, following the pit perimeter and then back into the original creek channel
- Option B. Realign the creek bypass upstream of the pit to the west between two natural hills and then around a small natural hill and then east back to the northern edge of the pit perimeter between the open pit and the northern WRD and then back into the original creek channel

- Option C. Realign the creek bypass upstream of the pit to the east around the pit perimeter between the open pit and the ROM pad and concentrator and then north and back into the original creek channel
- Option D. Realign the creek bypass and establish the diversion to the west between two natural hills and establish the channel to flow into a western arm of the Kerosene Camp Creek system
- Option E. Build a wall across the creek upstream of the pit and create an event pond to deal with storm events. Install a pump and pipeline and pump collected flow around the pit and back into the original channel
- Option F. Allow the creek to intersect with the pit and manage flow into the pit via the mine pumping system
- Option G. Mining of the western end of the deposit would not be undertaken and therefore the creek could remain in its original course.

The four realignment options considered (Options A through to D) are shown in Figure 4-2.

All options were investigated and assessed for their level of risk. Options A, B, C all require permanent diversion of the creek with regular prolonged road crossings for mining equipment and trucks that result in increased risks associated with the deposition of contaminated material into the creek bypass. They are also very close to dust sources, which present management challenges. These non-preferred options also feature difficulties in managing anticipated surface runoff from entering the creek system prior to monitoring and potential release.

Option D is the preferred option. This option also requires permanent diversion of the creek but keeps the creek diversion further away from mining activities and substantial ground disturbance, thereby reducing the risk of offsite contamination.

Options E and F present management and safety challenges, and Option G has significant economic implications for the project as a material quantity of ore would be excluded from the mining and processing inventory.

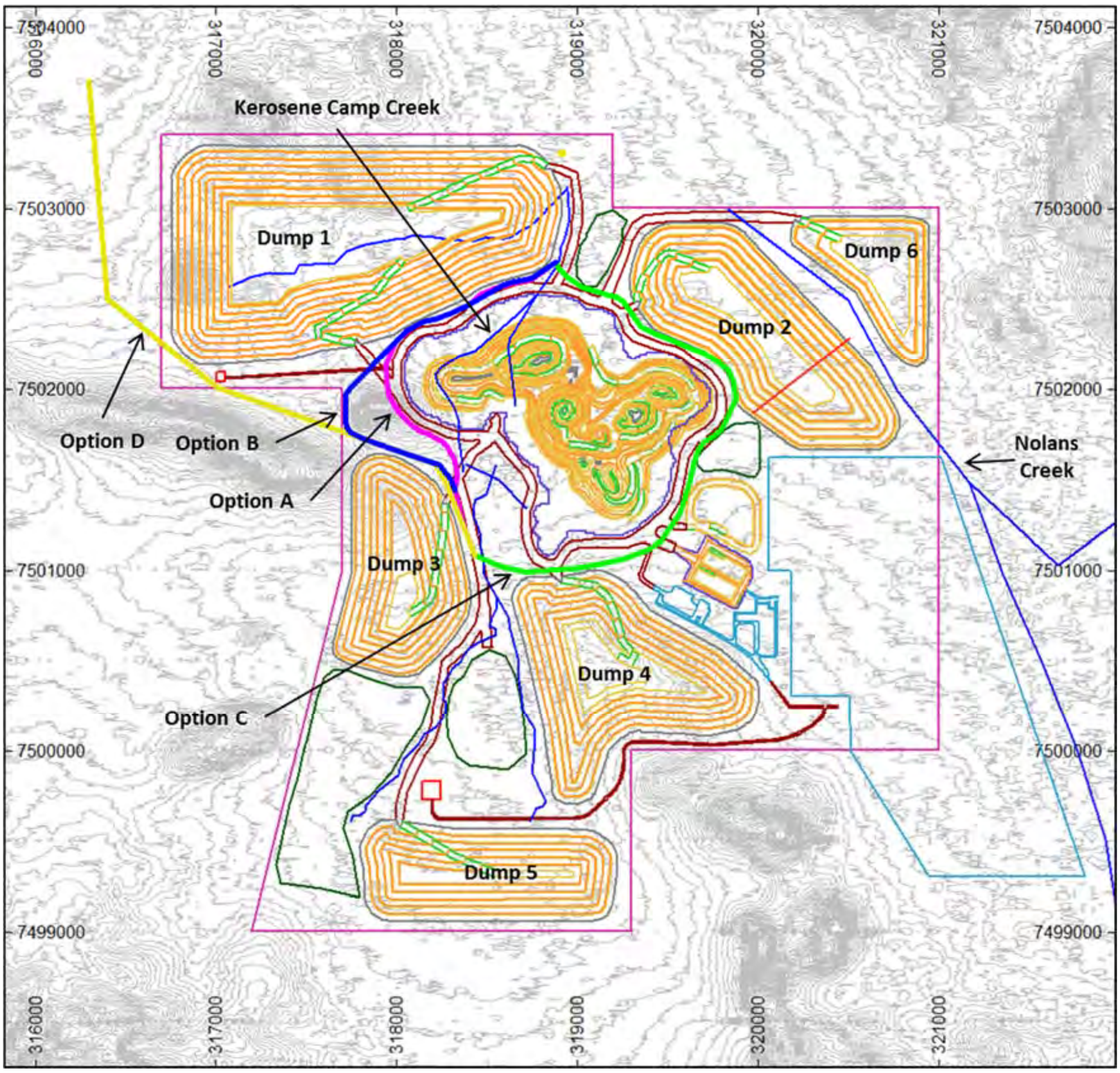


Figure 4-2 Kerosene Camp Creek Diversion Options (Source: Knight Piésold 2014)

4.3.13 Rehabilitation and closure

A closure concept design has been completed for the infrastructure components on the Nolans site, namely WRDs, TSFs and RSFs. These have been sited to avoid, as far as practicable, natural features on the site, and when completed and decommissioned will be rehabilitated to return the land to its pre-mining land use, that being pastoral activity.

It is proposed that all rehabilitation will be progressive on waste rock dumps, and the TSF and RSF cells will be closed down and rehabilitated during the operational phase of the project.

The mine and waste rock dumps are situated on a plain surrounded by natural rocky hills. The locations of the WRDs have been designed to avoid rectangular shapes to ensure they assume a more natural appearance when rehabilitated.

The nearby rocky hills are known to provide habitat for the Black-footed Rock wallaby and it is Arafura's intention during the final rehabilitation process to utilise larger waste rocks from the mining process to artificially create suitable habitat on the WRDs to encourage colonisation post mining.

These WRDs will also be designed as water-retaining structures i.e. to encourage water infiltration and assist vegetation establishment on the tops of the dumps. The tops of the dumps will be broken into a series of small cells so when it rains, water is retained and the vegetation can establish rapidly. These retention cells will also assist in reducing erosion risk from water discharge down the dump face.

Over the life of mine, a total of around 300 million tonnes of waste rock will be mined. Pegmatite and schist lithologies together account for about 25% of the total waste rock mass. The company's geochemical characterisation studies on waste rocks indicate that a small percentage (around 1%) of these particular waste lithologies may require additional management that could include encapsulation within benign waste rock. Confirmation of the quantity of waste rock that falls into this category will be determined pre-production following additional classification studies during pre-strip, etc.

In addition to geochemical characterisation, Arafura has developed a waste rock model to classify the rock lithologies into two broad categories based on radioactivity. A combination of analytical data and geophysical data was used to derive the model which classifies waste rock as either <1 Bq/g (i.e. benign), or >1 Bq/g (i.e. low-level naturally occurring radioactive materials, or low-level NORM). Very conservative parameters were used when constructing the model and consequently the amount of waste rock in the low-level radioactive waste category is likely to be overstated.

Waste rock >1 Bq/g will be managed by placing it within the waste rock dumps and covering it with benign waste rock. It should be noted that waste rock in this classification presents little or no risk to humans; nevertheless, it will be treated very conservatively. About 50% of the total waste rock mass falls into each of the above categories so there is adequate benign waste rock to provide a cover for all mine closure activities. One metre of benign material is more than adequate to encapsulate and shield radioactive material within the WRDs, or in the TSF and RSFs.

The open pit will remain as a pit void at the cessation of mining. The geometry and grade distribution of the Nolans Bore resource does not facilitate open pit mining by multiple pits, which might allow mining and backfill. Mining will commence in individual pits but these will quickly coalesce into a single large open pit as it deepens to access the orebody at depth. Arafura is yet to define the depth extent of the deposit. Arafura cannot justify deeper exploration drilling at present, and in any event, sufficient resources have been delineated to support 40+ years of production.

At the end of mining a pit lake will form in the bottom of the pit. The pit itself will be a natural water sink on the mine site with all natural mine site groundwater flowing into the pit rather than around or away from it.

Arafura is a member of the Minerals Council of Australia (MCA) and as such will, once operational, undertake audits to assess performance against the MCA's 'Enduring Values' charter. The company produces an annual sustainability report and this will be expanded when operations commence to report against the various management plans and objectives. The MCA produces best industry practice guidelines and these will be used to guide and assist rehabilitation and management programs at the Nolans operation. Arafura also intends to develop an integrated management system compliant with Australian ISO 14001, 4801 and 9001 standards. Following an implementation period, Arafura will seek third–party certification of this system.

4.4 Assessment of potential cumulative impacts

4.4.1 Projects

The location of the Nolans site is isolated from other major potential projects. The closest activities and other potential projects to the site are:

- Rum Jungle Resources Ammaroo phosphate mine about 100 km to the north east
- TNG Mt Peake titanium-vanadium mine about 140 km north
- Australian Abrasive Minerals Harts Range garnet mine, about 140 km south east
- KGL Jervois copper mine about 250 km east
- Tellus Chandler salt mine and waste storage facility about 250 km south.

The technical assessments provided in Chapters 7 to 19 provide a description of the existing environment and potential impacts that may result from the Nolans Project, including cumulative impacts.

Section 4.4 below summarises the cumulative impacts that may arise in combination with the projects identified above.

4.4.2 Cumulative socio-economic impacts

The cumulative socio-economic impacts are likely to impact on the larger geographic region, including Alice Springs, as a result of other large projects potentially going through construction and commissioning phases at the same time. Impacts may include drawing on a common workforce, services and supplies or creating cumulative pressures on key government services.

Other potential major projects in Central Australia in addition to those identified in section 4.4.1, include potential expansion of the Newmont Granites gold mine (Tanami) drawing on the same employment pool from around Ti Tree, and Central Petroleum and Metals X nickel-cobalt Wingellina project which may source supplies from Alice Springs.

Additionally, a proposed railway from Tennant Creek to Mt Isa, Jemena's proposed Northern Gas Pipeline and other potential construction projects in and around Alice Springs may also source supplies from Alice Springs. The timelines of these projects are uncertain, however some are imminent.

Some of the key potential positive cumulative impacts arising from concurrent resource project developments, including the Nolans Project, are:

- Opportunity for the establishment of shared regional infrastructure, leveraging off the resource developments (e.g. regional power station potentially providing competitively priced electricity for horticultural development)
- Growth of the horticultural sector around Ti Tree and the opportunity to provide produce to caterers working at accommodation villages (with shortly supply chains and more lucrative local markets)
- Collaborative employment and training programs for local Aboriginal people, both with other resource companies and Central Desert Regional Council
- Combined recruitment campaigns with other employers to encourage families to move to Alice Springs, including a potential pool of migrants moving to Alice Springs for work
- Greater capacity within the Central Australian service and supply industry, with reduced reliance on individual projects

- A greater population base in Alice Springs, with increased retail spending, a stronger regional economy and other spin-offs including more recreational facilities and sponsorships.

Potential adverse cumulative impacts include:

- The balance of water allocation to major projects in both Alice Springs and the broader Central Australian region are perceived to impact on communities, pastoral properties and horticulture
- Demand for accommodation in Alice Springs for both management staff, specialist contractors and FIFO workers impacting on tourism
- Pressure on potential employees and services in Ti Tree and Alice Springs, should both the Nolans Project and TNG's Mt Peake project start work within a similar timeframe
- Compounding workforce and recruitment shortages as people leave existing jobs to work at the mines, particularly for other businesses and the tourism and hospitality industry
- FIFO workers creating pressure on the cost and availability of flights to Alice Springs
- FIFO workers or those who relocate to Alice Springs to work on the projects, congregating in hotels and night spots, leading to antisocial behaviour
- The cumulative pressure of workers and their families exceeding available housing supply (rental and purchase), thus forcing prices and the cost of living up and increasing demand for public housing
- A negative image for the mining industry from wider concerns about legacy issues from mining.

4.4.3 Heritage

Whilst all Aboriginal archaeological places and objects are protected under NT legislation, destruction of some sites may be necessary to allow project activities to proceed. Without mitigation (such as avoiding certain types of landscape features), archaeological resources are also expected to be unknowingly impacted by the proposed infrastructure.

Whilst other projects will not directly impact the same places and objects affected by the Nolans Project, regionally there will be a cumulative increase in the potential impact to Aboriginal heritage across the Central Australian region, through the loss or damage of sites or objects.

4.4.4 Other impacts

The majority of water for the project will be sourced from the Southern Basins borefield. Modelled drawdown from the operation peaks at approximately six metres in the centre of the borefield. The predicted drawdowns are negligible in the Lake Lewis area and not likely to be measureable. Use of the Southern Basins borefield is not proposed by other projects and therefore no cumulative impacts due to other projects are considered likely.

Surface water impacts will be localised to the mine site and therefore will not be increased cumulatively by other projects or activities.

Impacts to flora and fauna have been assessed as relatively low and localised. It is likely that cumulative, localised impacts associated with significant numbers of resource projects in the region have the potential to impact on biodiversity conservation in Central Australian bioregions including the Burt Plain bioregion where the project is located. The Nolans Project has already, and will continue to, contribute to knowledge about the ecological integrity of threatened species populations in the local area.The implementation of a biodiversity management plan containing conservation activities including regular population monitoring surveys will aid this knowledge base. Additionally, Arafura will continue to review and be guided by the current threat abatement and recovery plans for listed species that are relevant to the project.

Traffic volumes on the section of Stuart Highway between Nolans and Alice Springs are relatively low and the incremental additional traffic resulting from the project is unlikely to have an impact on other highway users or highway safety. Any additional traffic from other projects is not expected to significantly restrict capacity of the highway network.

05

Risk assessment

5. Risk assessment

5.1 Introduction

This chapter provides a description of the whole-of-project risk assessment undertaken for the identification, assessment and management of project environmental risks associated with the Nolans Project.

The risk assessment provides a framework for identifying components of the project with the potential for greater environmental risk, and highlights areas of focus for environmental impact assessment and project specific control measures to minimise the likelihood and consequence of these identified risks.

Section 5.1 of the TOR for the preparation of an environmental impact assessment issued by the NT EPA for the Nolans Project required a risk assessment process that:

- Identified and discussed a range of risks presented by the project, including relevant potential direct and indirect impacts
- Assessed the risks with regard to their relative ranking to gain an understanding of the potential severity of impact. This ensured the reasons for the associated control measures were apparent
- Assigned levels of certainty about estimates of risk, incorporating consideration of the effectiveness of the planned controls
- Where applicable, recognised members of the community are expected to accept residual risks and their consequences.

This chapter describes the risk assessment methodology, outlines the key outcomes and rankings, and summarises the findings of the risk assessment.

The results of the risk assessment have provided a basis for evaluation and justification of the proposed controls or management measures to modify the risk. The impact pathways and proposed controls have been used to inform the Environmental Management Framework for the project, including the Environmental Management Plan (EMP) and associated sub plans.

5.2 Risk assessment methodology

The risk assessment process has been undertaken using a systematic approach consistent with *AS/NZS ISO 31000:2009 Risk management – Principles and guidelines*, which is schematically presented in Figure 5-1.

The early steps in the process involved establishing the context. Key considerations were setting the boundaries and the scope of the risk assessment, including an initial Project Description (Chapter 3), which formed the basis for the impact and environmental risk assessment.

After the context was established, technical specialists systematically identified potential cause-and-effect ‘pathways’ associated with the project, determining the links between project activities and the potential to impact on a given value or issue.

Once a preliminary risk register was completed by each technical specialist, a risk workshop was held to discuss the full range of risks. This workshop allowed technical specialists from key areas to discuss risks which were interrelated.

A risk assessment for socio-economic risks was completed in a separate risk assessment workshop. This allowed for methodical consideration of the potential social, economic and heritage impacts of the project, many of which are relatively distinct from other potential environmental impacts.

Risk workshops facilitated independently of the project team were conducted over five days and attended by a cross-section of internal stakeholders and technical specialists.

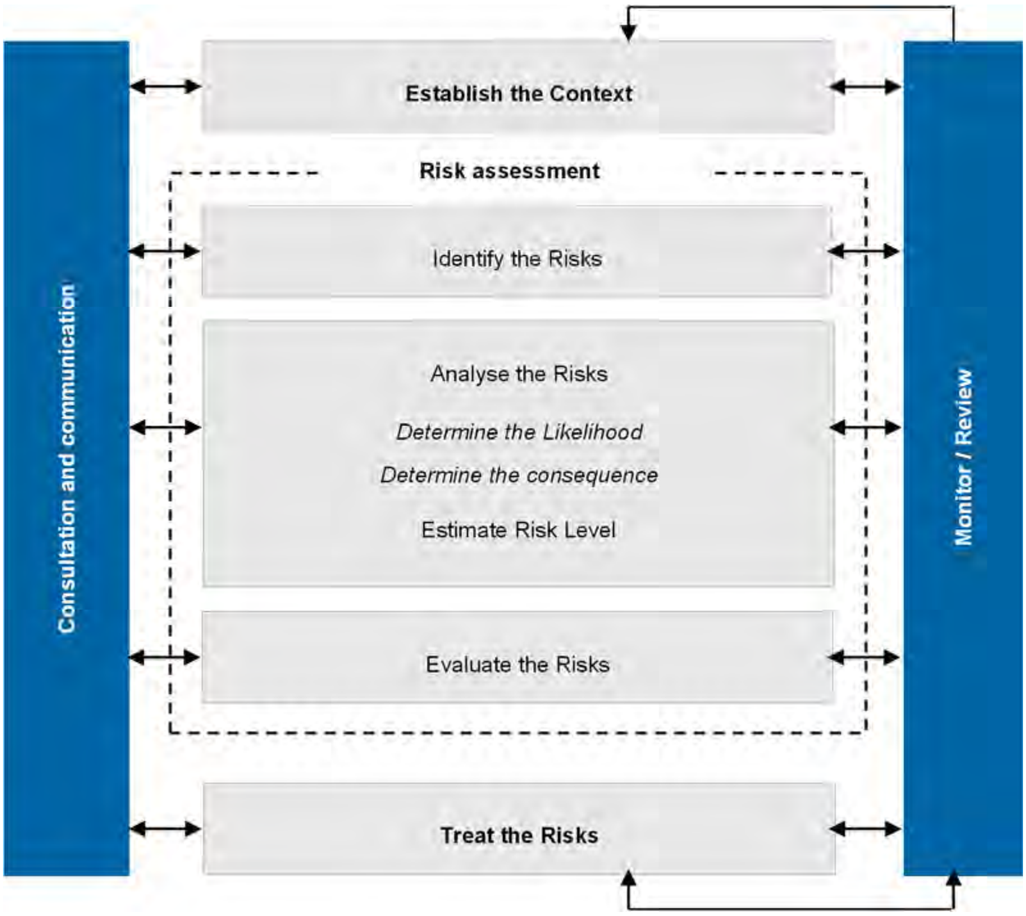


Figure 5-1 Risk management process (AS/NZS ISO 31000:2009)

5.2.1 Context establishment

The scope of the risk assessment included construction and operation, decommissioning, closure and post-closure risks of the project in relation to environmental, social and economic values on both a local and regional scale. An initial project description along with existing condition reports was used as a basis for the risk assessments. The project description provided details of the project footprint, project infrastructure requirements as well as construction and operational activities and processes. The project description also established the base level of planned controls that are inherent in the project design.

5.2.2 Risk identification

To determine risks, it is necessary to identify and describe cause and effect pathways for the project. Impact pathways identify the activity or event associated with project phases, and give consideration to assets, values and uses. This was done systematically for each discipline area to determine links between project activities and their subsequent consequences. The list of identified risks was developed using knowledge of the specific activities proposed for each component of the project across the phases, the local environmental context and understanding of the potential environmental or socio-economic impacts.

The risk assessment for socio-economic impacts identified both the negative impacts and positive opportunities that may accrue from the project, in order to minimise the socio-economic costs and maximise the benefits. This approach is in line with NT EPA *Guidelines for the Preparation of an Economic and Social Impact Assessment.*

5.2.3 Risk analysis and evaluation

Risk ratings were established for each pathway by technical specialists assigning a level of consequence in accordance with consequence criteria for the project (Table 5-1) and a level of likelihood in accordance with likelihood descriptors (Table 5-2).

Consequence criteria range on a scale of magnitude from ‘insignificant’ to ‘catastrophic’. Magnitude was considered as a function of the size of the impact, the spatial area affected and expected recovery time. These were influenced by the requirements of relevant legislation and guidelines.

Some risk events can have consequences on multiple environmental receptors. To provide a meaningful and manageable risk register, these potential impacts were grouped as a risk event with each potential impact assessed separately.

The initial risk rating considered the consequence and likelihood of the risk event with planned controls in place. These controls are consistent with the project description, regulatory requirements and management measures for projects of this nature (refer to the EMP contained in Appendix X).

Risks were assessed considering the maximum credible consequence level. Combining the assessed level of consequence and the likelihood of that consequence occurring provides guidance on the risk rating (Table 5-3). The risk was then assessed against relevant criteria as shown in Table 5-4 to determine if additional actions are required to be taken, or if the risk is at a tolerable level.

In addition to the risk ratings, the assessment applied a certainty level to each overall risk rating based on the information and data available, as listed in Table 5-5. The certainty assessment incorporated consideration of the effectiveness of the planned controls to manage the risk and was able to be used to assist in determining if further actions should be focused on in order to manage risks.

5.2.4 Risk treatment

Where practicable, additional control measures were developed to further reduce the risk. In the case of the social risk assessment where the impacts are positive in nature, the risk treatment included actions to optimise or enhance these benefits for local and regional communities.

The risk was reassessed with planned and additional controls in place to confirm the effect of the additional control measures. This second rating is known as the residual risk rating.

The control measures have been used in developing the EMP (Appendix X) and associated monitoring programs, where applicable. The controls are actions to be implemented in the delivery of the project through the construction, operation, decommissioning, closure and post-closure phases.

5.3 Risk register

A risk register was established to document the findings of the risk assessment process, presented separately for environmental and socio-economic risks. The risk register contains details of impact pathways, their consequences, planned controls inherent in the project description, an initial risk assessment, additional controls, and the residual risk rating. These are presented in Appendix F (environmental) and Appendix G (social).

Table 5-1 Project consequence descriptors

Aspect	Insignificant	Minor	Moderate	Major	Catastrophic
Air quality	No measurable air quality impacts or exceedance of air quality standards	Local, short-term, and approaching exceedance of air quality standards	Local, minor, long-term, or widespread minor short-term or exceedance of air quality standards	Widespread (regional), major, short-term exceedance of air quality standards	Regional long term change in air quality or exceedance of air quality standards
Biodiversity: Listed flora species	Minor local habitat modification and/or lifecycle disruption for a listed species	Moderate local habitat modification and/or lifecycle disruption for a listed species	Substantial local habitat modification and/or lifecycle disruption for a listed species	Moderate regional habitat modification and/or lifecycle disruption for a listed species	Substantial regional habitat modification and/or lifecycle disruption for a listed species
Biodiversity: Listed threatened fauna species	No loss of individuals of listed fauna species	Minor local decrease in size of population(s) of listed fauna species	Moderate local decrease in size of population(s) of listed fauna species	Substantial local decrease in size of population(s) of listed fauna species	Moderate or substantial regional decrease in size of population(s) of listed fauna species
Biodiversity: General flora and fauna	Insignificant or imperceptible effects	Local short term decrease in abundance of some species with no lasting effects on local population	Local long term decrease in abundance of some species resulting in some change to community structure	Regional decrease in abundance of some species resulting in some changes to community structure	Regional loss of numerous species resulting in the dominance of a few species
Historic and cultural heritage: Aboriginal and cultural heritage	Minor repairable damage to common structures or sites. No disturbance of historic and / or cultural heritage sites	Moderate or repairable damage or infringement to sensitive structures or sites of cultural significance or sacred value	Considerable damage or infringement to sensitive structures or sites of cultural significance or sacred value	Major damage or infringement to sensitive structures or sites of cultural significance or sacred value	Irreparable and permanent damage to sensitive structures or sites of cultural significance or sacred value
Human health and safety: Safety	Low level short term subjective inconvenience or symptoms. Typically first aid and no medical treatment.	Reversible / minor injuries requiring medical treatment, but does not lead to restricted duties. Typically a medical treatment.	Reversible injury or moderate irreversible damage or impairment to one or more persons. Typically a lost time injury.	Single fatality and/or severe irreversible damage or severe impairment to one or more persons.	Multiple fatalities or permanent damage to multiple people.

Aspect	Insignificant	Minor	Moderate	Major	Catastrophic
Human health and safety: Health	Reversible health effects of little concern, requiring first aid treatment at most.	Reversible health effects of concern that would typically result in medical treatment.	Severe, reversible health effects of concern that would typically result in a lost time illness.	Single fatality or irreversible health effects or disabling illness.	Multiple fatalities or serious disabling illness to multiple people.
Radiation: Occupational exposure	<1 mSv/y. Measurable increase in radiation dose with outcomes below public dose limit.	<5 mSv/y. Measurable increase in radiation dose with outcomes remaining below dose constraints.	>5 mSv/y and <20 mSv/y. Measurable increase in radiation dose with outcomes between action level and dose limit (average over five year period).	>20 mSv/y and <50 mSv/y. Measurable increase in radiation dose with outcomes between dose limit (average over five year period) and maximum annual dose.	>50 mSv/y. Measurable increase in radiation dose with outcomes greater than the maximum annual dose.
Radiation: Public exposure	No change from background. Dose not discernible above natural background.	<0.3 mSv/y. Measurable increase in radiation dose with outcomes below public dose constraint.	>0.3 mSv/y and <1 mSv/y. Measurable increase in radiation dose with outcomes between dose constraint and dose limit (averaged over five years) for public.	>1 mSv/y and <5 mSv/y. Measurable increase in radiation dose with outcomes between dose limit (averaged over five years) and maximum annual dose for public.	>5 mSv/y. Measurable increase in radiation dose with outcomes greater than the maximum annual dose for public.
Radiation: Environmental impact	ERICA* RQ < 0.1	ERICA RQ >0.1 and <1.0	ERICA RQ >1.0 plus justification	ERICA RQ >1.0 and no justification	ERICA RQ > 10.0
Socio-economic: Community	Local, small-scale, easily reversible change on social characteristics or values of the communities of interest or communities can easily adapt 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 some capacity to adapt and cope with change.	Long-term recoverable changes to social characteristics and values of the communities of interest or community has limited capacity to adapt and cope with change.	Irreversible changes to social characteristics and values of the communities of interest or community has no capacity to adapt and cope with change.

Aspect	Insignificant	Minor	Moderate	Major	Catastrophic
Transport: Traffic and transport operations and conditions	Negligible adverse impact on traffic and transport conditions. No perceptible deterioration of road integrity.	Detectable adverse changes in traffic and transport condition (decrease in Level of Service) at one or two locations at any one point in time during the construction period or at a single location during operations. Seasonal, local deterioration of road integrity.	Detectable adverse change in traffic and transport conditions (decrease in Level of Service) at multiple locations. Short-term, local deterioration of road integrity.	Traffic and transport congestion and delays exceed acceptable levels at multiple locations. Short-term, regional deterioration of road integrity.	Traffic and transport congestion and delays severely restrict the safe operation and efficiency of the transport network. Long-term, regional deterioration of road integrity.
Transport: Road safety on public roads	No increase in vehicle incidents along relevant haulage routes above historical baseline trend.	An increase in vehicle incidents along relevant haulage routes of five per cent above historical baseline trend.	An increase in vehicle incidents along relevant haulage routes of ten per cent above historical baseline trend.	An increase in vehicle incidents along relevant haulage routes of twenty per cent above historical baseline trend.	An increase in vehicle incidents along relevant haulage routes of greater than twenty per cent above historical baseline trend.
Water: Surface water	Minimal contamination or change with no significant loss of quality.	Local minor short term reduction or change in water quality. Local contamination or change that can be immediately remediated.	Local minor long term or widespread minor short term or local major short term reduction or change in water quality. Local contamination or change that can be remediated in long term.	Widespread (regional) major short term reduction or change in water quality. Local contamination or change that cannot be remediated in long term. Widespread contamination or change that can be remediated.	Regional long term reduction or change in water quality. Widespread contamination or change that cannot be immediately remediated.
Water: Groundwater	Negligible change to groundwater regime, quality and availability.	Changes to groundwater regime, quality and availability but no significant implications.	Changes to groundwater regime, quality and availability with minor groundwater implications for a localised area.	Groundwater regime, quality or availability significantly compromised.	Widespread groundwater resource depletion, contamination or subsidence.

* Note ERICA is tool for the assessment of impacts of radiation on non-human biota where RQ is the risk quotient value.

Table 5-2 Project likelihood descriptors

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

Table 5-3 Project risk matrix

	Consequence				
Likelihood	**Insignificant**	**Minor**	**Moderate**	**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

Table 5-4 Risk criteria

Rating	Approach
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.

Table 5-5 Project data availability descriptors

Descriptor	Explanation
Low Level	Risk rating is based on subjective opinion or relevant past experience.
Medium Level	Risk rating is based on similar conditions being observed previously and/or qualitative analysis.
High Level	Risk rating is based on testing, modelling or simulation, use of prototype or experiments. Analysis is based on verified models and/or data. Assessment is based on an historical basis.

5.4 Discussion of key outcomes

5.4.1 Risk assessment results

The environmental risk assessment identified 81 risk events, of which several had potential impacts on multiple environmental receptors. As a result, 135 impact pathways were identified and assessed through the environmental risk assessment process.

The separate social risk assessment identified and assessed 22 socio-economic risk events, of which 18 were potential negative impacts and four were potential positive impacts. Table 5-6 reflects only negative impacts, and its total of 20 socio-economic risk events includes two community risks and the 18 negative socio-economic risks from the social risk register.

The residual risk rating for most risks was rated as Low (Figure 5-2). Those rated Medium or High were the subject of particular attention in the development of further control measures and management plans.

The risk profile across the study area is presented in Table 5-6 and Figure 5-3, which highlight the distribution of project risks per environmental aspect. This shows that the highest number of risks is associated with Human Health and Safety followed closely by Fauna and Socio Economics. There were no risks identified and assessed with an Extreme risk rating.

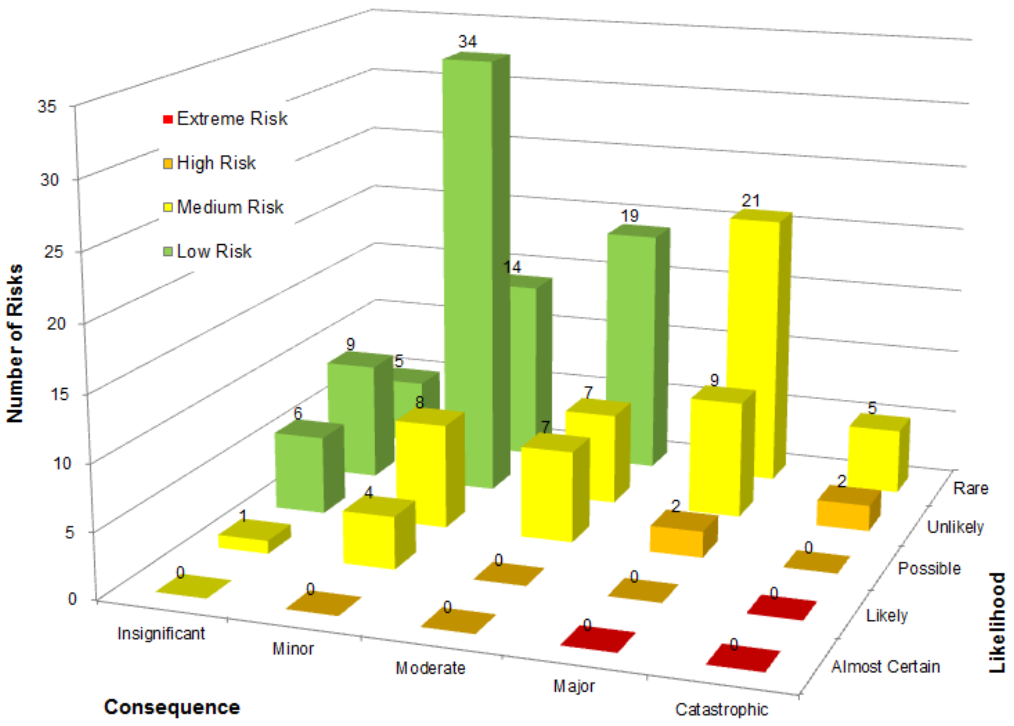


Figure 5-2 Whole-of-project residual risk ratings

Table 5-6 Summary of residual risk ratings by study area

Study Area	Low	Medium	High	Extreme	Total
Air quality	5	2	0	0	7
Socio-economic	12	7	1	0	20
Fauna	16	5	0	0	21
Flora	13	4	0	0	17
Groundwater	10	7	0	0	17
Historic and cultural heritage	4	1	0	0	5
Human health and safety	0	23	2	0	25
Mine closure	4	4	0	0	8
Radiation	12	2	0	0	14
Surface water	11	4	0	0	15
Transport	2	2	0	0	4
Total	89	61	3	0	153

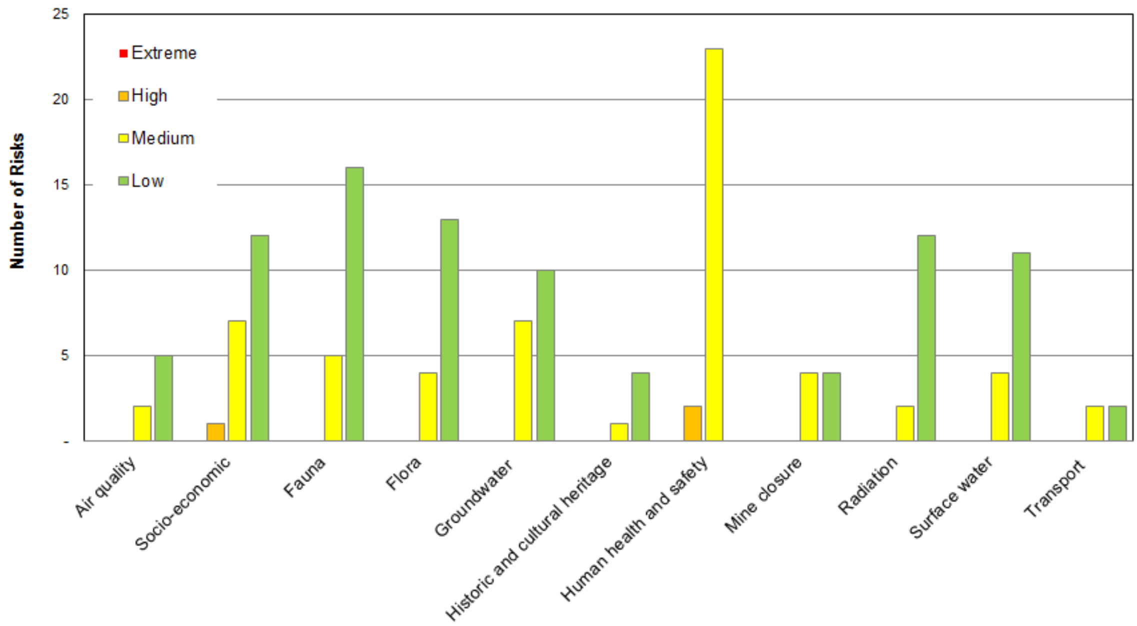


Figure 5-3 Distribution of residual risk ratings by study area

Key risk areas that were subject to further detailed impact assessment and risk management planning include the following:

- Health and safety of project personnel from interaction with equipment as well as mobile and fixed plant, during construction and operation activities
- Dust fallout and deposition, including impacts to fauna and nearby sensitive receptors, from wind erosion of exposed surfaces and vehicle movement along haul roads
- Flora, vegetation communities and fauna habitat impact from spread of weeds and feral animals due to vehicle movements and/or inappropriate waste management
- Groundwater quality from seepage, embankment failure or overtopping of tailings, residue storage facilities and/or process liquor evaporation ponds
- Decline in availability of water to existing and/or future users, within the Southern basin from progressive water table drawdown arising from groundwater extraction rates
- Social and family tensions from increased disposable income and distribution of benefits payments in the local communities
- Employment impacts to existing local businesses (e.g. retail, hospitality, council) due to recruitment of project personnel
- Wellbeing of project personnel due to living away from home and lack of family / support networks.

After the application of additional control measures, the residual risk profile changes slightly from Figure 5-3 to that presented in Figure 5-4. It demonstrates that:

- The majority of risks are unlikely or may occur only in exceptional circumstances
- The maximum credible consequence of most risks is no greater than a minor impact.

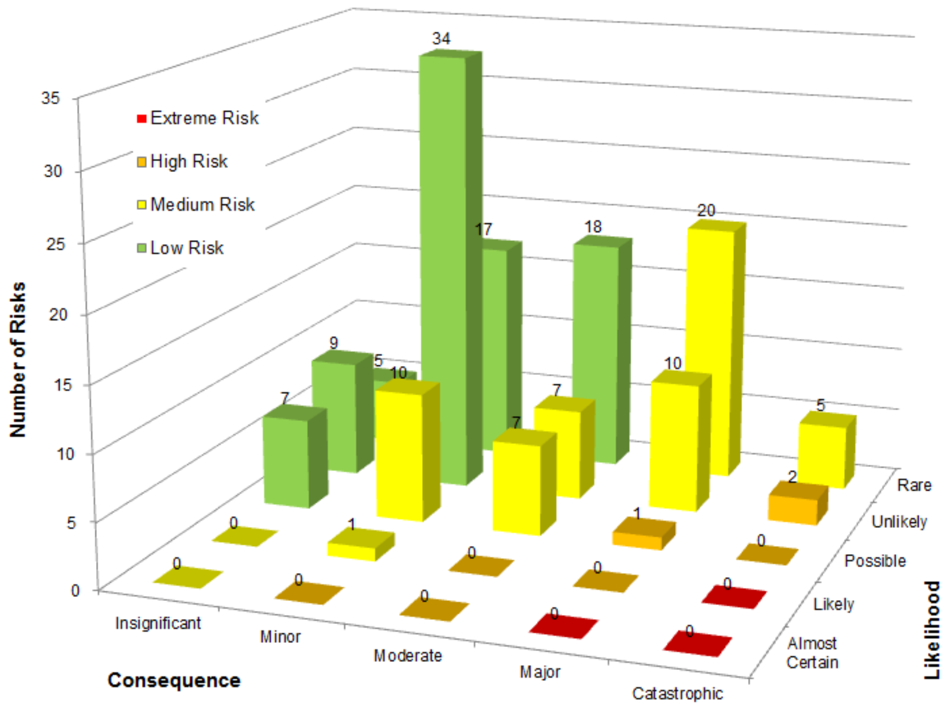


Figure 5-4 Whole-of-project residual risk ratings after additional control measures

There are however, a range of medium level risks which will be actively managed through identified control measures. No risk was assessed as having an initial or residual risk rating of extreme. The top three risks have a residual risk rating of high, and have been acknowledged as key areas for management:

1. Vehicle incident associated with the transport of materials and personnel off-site on public roads
2. Mobile equipment incident on site, including all operational areas and vehicle types
3. Project personnel mental health issues, including potential for self-harm, associated with or exacerbated by living away from home and lack of family / support networks.

5.4.2 Key control measures

Key controls for the management of identified risks are covered in the EMP (Appendix X) for the project, which encompasses the following sub plans:

- Air and Dust Management Plan
- Biodiversity Management Plan
- Cultural Heritage Management Plan
- Emergency Response Plan
- Fire Management Plan
- Hazardous Substances Management Plan
- Mine Closure Plan
- Non-mineralised Waste Management Plan

- Acid Metalliferous Drainage Management Plan
- Water Management Plan
- Erosion and Sediment Control Plan
- Weed Management Plan and
- Social Impact Management Plan.

5.5 Conclusion

A risk based approach was adopted to identify and assess potential impacts associated with the project, in terms of their credible worst case consequence and the likelihood of that consequence occurring.

The risk assessment was conservative in approach, to provide reputable results. A summary was developed of the findings that describe the activities of the project and the prioritisation of the associated risks. The results of the risk assessment have been reported in the individual impact assessment report for each specialist study area, providing justification for the rating and outlining additional control measures to manage the risk.

The risk identification and additional control measures have been used to inform the Environmental Management Framework for the project, and in particular the aspects in the EMP and associated sub plans.

06

Consultation

6. Consultation

6.1 Introduction

This chapter describes the consultation process, and key themes raised during consultation, for the proposed Nolans Project. The chapter is based on the *Nolans Project Community Consultation Report* (Michels Warren Munday 2016) provided in Appendix H of the EIS.

This chapter summarises the public consultation between 2007 and December 2015 by, or on behalf of, Arafura. The Community Consultation Report (Appendix H) and chapter address various sections of the TOR.

The approach to community consultation included consideration of the:

- NT EPA TOR
- NT EPA Guidelines for preparation of an Economic and Social Impact Assessment (November 2013)
- International Association of Public Participation (IAP2) Spectrum of Participation and
- *Enduring Value* – Australian Minerals Industry Framework for Sustainable Development (that describes sustainable development as investment in minerals projects that are “financially profitable, technically appropriate, environmentally sound and socially responsible)”.

6.2 Consultation strategy

Consultation for the project began in 2007 when the project was first announced. In addition, a consultation and communication strategy was prepared to guide the environmental impact assessment process.

The consultation goal is to build the relationships, trust and understanding necessary for Arafura to operate in partnership with Central Australian stakeholders and community groups, to capture their aspirations and concerns, and deliver good social outcomes.

The objectives of the consultation strategy include:

- Give Northern Territory and Australian Government regulators confidence that Arafura has informed and listened to stakeholders and the general community
- Ensure social, economic and environmental impacts arising from the project are clearly defined and appropriate management strategies are established to deal with them
- Maintain the confidence of the community and government that Arafura can be trusted to responsively manage all social, environmental and economic impacts and communicate with cultural sensitivity, transparency and openness
- Provide accurate, relevant and timely communication so stakeholders can provide informed input
- Identify all stakeholders and seek their views to inform good decision-making
- Establish a good risk management approach to identify and respond to issues early.

The information and feedback collated during the consultation process has contributed to the social impact assessment (Appendix S) and the social impact management plan (SIMP) (Appendix X). The SIMP outlines strategies for ongoing community engagement and communication to maintain relationships and keep the community informed, particularly once the company makes a decision to proceed with the project.

6.3 Consultation activities

6.3.1 Key stakeholders

Consultation included the following key groups:

- Government departments, agencies and regulators
- Central Desert Regional Council and local authorities
- Central Land Council (CLC)
- Aboriginal communities and traditional owners
- Alice Springs Town Council
- Arid Lands Environment Centre
- Non-Government organisations such as NT Shelter, Waltja Tjutangu Palyapayi and the Multicultural Community Services of Central Australia
- Aileron Roadhouse
- Pastoralists
- Various business entities including Chamber of Commerce, local businesses, other mining companies, employment and training services providers and
- Environmental groups in Darwin and Alice Springs.

6.3.2 Consultation activities

Consultation included:

- 189 stakeholder meetings, including meetings with government departments, agencies and regulators
- 36 dedicated SIA interviews
- Public presentations to industry and business groups, and participation over several years at the Annual Geoscience Exploration Seminar in Alice Springs
- Briefings, presentations, a dedicated project webpage and written communication with stakeholders
- Site visits with key stakeholders
- Attendance at local events
- Community meetings with traditional owners.

6.4 Consultation outcomes

Table 6-1 summarises key issues raised by stakeholders throughout the consultation meetings and events.

Table 6-1 Stakeholder issues and responses

Summary of key issues	Response
Land and water	
Concerns related to impacts on the quality and availability of drinking water and potential for contamination of aquifers. Concerns about the implications of diverting Kerosene Camp Creek. Expectations that Arafura's drilling for water might address the quality and availability of supply to communities, and improve productivity in more barren parts of pastoral properties.	Arafura moved the intermediate processing plant from its initial surface water catchment, following the discovery of substantial groundwater in a deeper aquifer system with few other competing users. Hydrological studies suggest the connection between the Southern Basins and Ti Tree aquifer in an area referred to as The Margins is primarily a subtle groundwater divide with water flowing north of the divide to the Ti-Tree Basin and south of the divide to the Southern Basins. Hydrological studies suggest a low level of impact on Laramba's groundwater supplies, from drawdown or changes in water chemistry. Chapter 7 Surface water summarises impacts to surface water resources including Kerosene Camp Creek diversion. Chapter 8 Groundwater summarises potential impacts to groundwater resources.
Concerns related to impact on visual amenity and the loss of habitats through clearing and fragmentation.	There will be vegetation clearance and ecological studies suggest limited potential impacts on biodiversity (refer to Chapter 9 Biodiversity). There are opportunities for rangers and local people's involvement in ongoing land management.
Concerns regarded impacts from climate change on the project and local area, including increased demand for water as the temperature rises	Water modelling has been undertaken over time and using long-term climate data (refer to Chapter 7 Surface water and Chapter 8 Ground water).
Concern was raised relating to the cumulative impacts of multiple resource projects.	Cumulative impacts are discussed particularly in social impacts (Chapter 15) and biodiversity (Chapter 4) and transport (Chapter 17).
Waste and chemical storage and transport	
Concerns associated with long term storage and management of waste including waste rock and process residue. Particular concerns are uranium and thorium storage and associate health risks, risks of pollution and of tailings dam failures.	All waste will remain on site in engineered storage facilities that are designed in accordance with ANCOLD guidelines. At closure the waste storage facilities will be closed and capped in accordance with mine closure criteria, thus posing a low risk to the public or the environment (refer Chapter 18 mine closure). The presence of uranium and thorium is not expected to exceed naturally occurring background levels of radiation following mine closure. During operations all workers will be monitored regularly to record the level of radiation they are exposed to so Arafura can ensure this exposure does not exceed approved public health levels (Chapter 12 Radiation).
Concerns about chemicals used and the safe transport of these to and from site.	Chemicals will be transported by rail to a loading facility in Alice Springs, then moved to the project site by truck and stored on site. All storage and transportation will comply with Australian Standards. Appropriate

Summary of key issues	Response
	emergency response protocols will be in place in the event of a spillage or an incident (refer to Chapter 11 Human health and safety).
Transport and road safety	
Concerns about increased industrial traffic on the Stuart Highway and access roads on the Aileron station, and the likely impact on local roads Concerns about public road safety.	There will be two road trains working seven days a week on the public road network, and 26 daily one-way-trips will be added to the road network, including daily FIFO buses. The forecast indicates that operations at the site are likely to result in low impacts on the existing road network. FIFO buses are included in this trip generation calculation, and workers will be transported to site by bus to reduce risk. Arafura is working with the Department of Transport to meet safety requirements at intersections. The site access route would be via an existing station track to the Stuart Highway, not via the Napperby Road. All station roads affected by the project will be maintained. Arafura will implement an emergency management plan. Medical facilities will be available on site and operate under remote protocols with Alice Springs Hospital, the Ti Tree Health Clinic and the Royal Flying Doctor Service.
Impact on council and government services	
Concerns that the project will create an influx of people to the local area and put pressure on nearby aboriginal communities Concerns that local employers will lose staff to the mine site and that local and regional services including medical, childcare, housing and utilities for example would be put under pressure from increasing demand	Arafura expects about 95% of its construction workforce and 90% of its operations workforce to be FIFO, given the tight labour market in Central Australia and competing projects. Arafura will work collaboratively with the Council on its workforce development training and recruitment, but some loss of staff to the mine is inevitable. Arafura understands that its workers may create both positive and negative impacts on the local housing market. It will monitor the impacts of accommodating workers, house FIFO workers in temporary accommodation and look at a range of options for managing impacts, such as purchasing and building temporary accommodation. Refer Chapter 15 socio-economic impacts.
Impact on employment and education	
Concerns relating to the barriers to employment for Aboriginal people Concerns over the attractiveness of Alice Springs to encourage relocation by workers.	Employment and training of local Anmatyerr Traditional owners is a priority for Arafura. Arafura is interested in collaborating with other companies operating in Central Australia to run a combined recruitment campaign to encourage potential workers to relocate to Central Australia. This will need to address issues such as lifestyle, health, schooling and community infrastructure.

Summary of key issues	Response
Concerns regarded FIFO workers who would not contribute to the local economy and may cause negative impacts.	Arafura will prioritise local jobs, however a sufficient local labour force may not be available locally, particularly with the likely peak demand during construction and for specialised positions. Arafura will monitor all impacts of employment to minimise social impacts arising from a large construction workforce and adapt its strategy accordingly. Refer Chapter 15 socio-economic impacts.
Concerns that workers would be poached from other local employers.	Arafura is conscious that it may poach good workers from other employers and would work with all parties on a coordinated approach to local employment and training, but this issue is largely out of Arafura's control. Arafura will contribute to a regional workforce strategy that takes account of the skills of all regional employers. Training by the mine will provide professional development and skills that deliver long-term benefits to the region's capacity and individual employers as staff move between jobs. Refer Chapter 15 socio-economic impacts.
Economic development and business opportunities	
Expectation relating to local procurement, improvements to local infrastructure and ensuring benefits are realised during operation. Expectations were raised for new industries and improving quality and safety standards of local businesses. Concerns were raised that local businesses would not be able to complete with larger interstate firms.	Arafura will prioritise the use of local businesses who can meet the company's safety, quality and reliability standards and who are commercially competitive. Arafura will work closely with the Industry Capability Network to identify local companies able to provide services and seek advice on works packaging to maximise local participation. The Aileron Roadhouse will provide overflow accommodation for the project during construction and operations. Arafura will work with the NT Government, Chamber of Commerce and ICN to provide timely and relevant communication on likely opportunities, how to win work and standards that would be expected of all services and supplies. Refer Chapter 15 socio-economic impacts.
Expectations related to employment opportunities for Aboriginal people and women. Concerns regarded health issues, training needs and social issues connected with local populations.	Employment and training of local people, in particular Anmatyerr traditional owners, is a priority for Arafura. Arafura will put in place a range of workforce measures to maximise the success of Aboriginal employment and training, including opportunities in the project's supply chain with sub-contractors and labour hire arrangements with a local provider. Arafura will implement an employment and workplace strategy that addresses immediate and long-term opportunities. Refer Chapter 15 socio-economic impacts.

Summary of key issues	Response
Suggestions made for Aboriginal enterprises including horticultural and involvement in the supply chain.	Arafura will work with the CLC and the Department of Business to help Aboriginal people realise ambitions of enterprise development based on opportunities at the mine. Refer Chapter 15 socio-economic impacts.
Expectations are that economic development would be sustainable and not displace existing industries i.e. tourism.	Arafura will produce an annual sustainability report, to include reporting on commitments such as local jobs, procurement, development of new economic sectors and general contributions to the sustainable development of the Central Australian economy. Refer Chapter 15 socio-economic impacts.
Concerns raised from pastoralists relating to access arrangements, competing land uses and impacts to proposed organic farming.	Arafura will negotiate access arrangements with the pastoral properties affected by the project.
Culture and heritage	
Expectation that Aboriginal connections to country are respected and that access to land for traditional activities would be maintained.	Arafura will incorporate cultural awareness training for staff and strict codes of conduct to maintain respect for Aboriginal connections to country. There may be opportunities for traditional owners to develop small businesses to provide tourism and cultural awareness programs. Arafura will consult with traditional owners about land access issues, and take account of important areas in considering the location of mine infrastructure. Refer to Chapter 16 Historic and cultural heritage.
Concern that sacred sites and Aboriginal would be impacted.	Arafura will obtain the appropriate clearance certificates and, where necessary, the approvals to remove or destroy sites that cannot be avoided. Arafura will work with traditional owners to discuss protection of key sites of significance. opportunities to commemorate the early history of the region through communication about the project, link to tourism ventures and provide interpretive signage, would be considered (refer to Chapter 16 Historic and Cultural Heritage and Appendix X Cultural Heritage Management Plan.)
Other social impacts	
Concerns that cash royalties and/or would have a negative social impact and could result in family conflict and alter the character, cohesion and resilience of a community. Expectation of real community benefits for traditional owners	Arafura is negotiating an agreement with native title claimants, through the CLC, that will include a focus on community benefits rather than cash payments. The CLC has an investment policy and promotes the benefits of community development. An agreement will be negotiated with the CLC on behalf of Native Title Holders. The CLC's role is to ensure that benefits are distributed to the rightful claimants.

Summary of key issues	Response
Housing stress associated with Aboriginal people moving into the local area because of work Broad concern about the impact of a large group of workers on housing availability and affordability	Arafura will implement an employment and workplace strategy that includes drug and alcohol policies, healthy lifestyle programs and codes of conduct for workers. Management plans will include volatile substance abuse awareness.
Corporate Social Responsibility	
Concerns of legacy issues from mining in the territory, long term rehabilitation, safety and mine closure.	Arafura understands that its workers may create both positive and negative impacts on the local housing market. It will monitor these impacts and will look at purchasing or building additional, temporary accommodation if necessary.
Expectation of sponsorship of local community events, education and sports.	Arafura will develop a sponsorship policy closer to the project starting. Sponsorship and community benefits programs will prioritise projects and activities that foster healthy lifestyles, leadership, discipline and safety.
Expectation of good communication and ongoing engagement with stakeholders.	Arafura adopted a strong engagement approach from the outset and will continue this approach. Arafura will continue to communicate elements of the project, using strategies tailored to suit various audiences.

6.5 Ongoing community consultation

Arafura will continue to communicate elements of the project, using strategies tailored to suit various audiences. Ongoing community consultation and engagement will aim to continue building relationships and provide stakeholder groups with continued opportunities to input into project considerations.

In the event project approval is granted and the project proceeds, Arafura will establish and implement a community consultation/social impact management plan that is likely to include:

- Ongoing community engagement
- Establishment of a community reference group - with membership drawn from interested stakeholder groups and a cross-representation of traditional owner and community families
- Appointment of a community liaison officer - to work with the community
- Development of a communication and community relations strategy to maintain a mechanism for community feedback and consultation about potential relevant impacts as the project evolves
- Development of evaluation procedures to community attitudes towards Arafura and the Nolans Project and project communication.

For more detail, refer to the draft Social Impact Management Plan provided in Appendix X.

07

Surface water

7. Surface water

7.1 Introduction

This chapter describes the existing surface water characteristics and potential impacts on surface water resources within and around the proposed Nolans site. A detailed surface water report is provided in Appendix I of the EIS.

Section 5.3 of the TOR for the project provided the following environmental objectives in relation to surface water resources:

> *Water resources will be protected both now and in the future, such that ecological health and land uses, and the health, welfare and amenity of people are maintained.*
>
> *Proposed creek diversion(s) will maintain equivalent ecological functionality of the waterways, and minimise impacts to linked riparian and aquatic ecosystems for the short and long term.*

This chapter addresses the potential impacts on surface water resources within and around the Nolans site for all stages of the project as required in the TOR. Groundwater resources are discussed in Chapter 8 of this EIS.

7.2 Methodology

A summary of the approach to assessment of surface water resources in the study area is described below and more detail is provided in Appendix I.

Key tasks involved in the preparation of the surface water impact assessment included:

- Desktop review to identify data relating to surface water resources within the study area and identify potential surface water monitoring locations
- Site visit in January 2011
- Surface water quality records obtained from the NT DLRM water data portal
- Rainfall-runoff model (XP-RAFTS) to derive flood peak discharge along the two creeks flowing through the proposed mine site (Kerosene Camp Creek and Nolans Creek)
- 2-D rain-on-grid flood modelling to obtain the extent and depth of flooding during a 1 in 1000-year average recurrence interval (ARI) event together with an indication of flow velocity at locations across the Nolans site
- 1-D flood routing model to investigate the hydraulics of the Kerosene Camp Creek diversion (Appendix A of Appendix I).

7.3 Existing environment

This section describes the surface water resources and related features identified in the study area, and discusses the relative value of the features in the local and regional context.

7.3.1 Topography and land use

The proposed Nolans mine site is at the head of the Kerosene Camp Creek valley on the north facing slopes of an east – west trending ridge of the Reynolds Range, and the processing site is situated on the southern slopes of the same ridge. Topographic elevation is 886 m above sea level (m ASL) at Mt Boothby to the east of the mine site, and 1,006 m ASL at Mt Freeling to the west (Figure 1-6). Most of the Kerosene Camp Creek valley floor at the mine site is typically between 650 and 700 m ASL whilst the processing site is at an elevation of about 670 m ASL. Longitudinal gradients along local creeks to the north and south of the ridgeline are typically less than 0.5 percent with steeper gradients of about 10 percent on isolated hills.

The Nolans site, with the exception of the western part of the borefield, lies wholly within Aileron Station, which is currently operating rangeland cattle grazing.

Third party infrastructure in the vicinity of the Nolans site includes:

- APA Group's Amadeus Basin to Darwin gas pipeline which runs south west to north east along the south eastern boundary of the processing plant and is buried to a depth of about 1 m
- The Stuart Highway which runs north – south about 10 kilometres east of the Nolans site but does not cross surface watercourses downstream of the Nolans site and
- Napperby Station / Laramba access road which runs east – west about 12 kilometres south of the processing site and traverses minor surface watercourses downstream of the processing plant.

7.3.2 Rainfall and evaporation

Prevailing winds are from the southeast and mean monthly minimum and maximum temperatures range between 4.9 °C in July and 37.6 °C in January. Mean annual rainfall at Nolans site is about 310 millimetres and mean annual potential evaporation is about 2,400 millimetres.

Annual total rainfall is erratic from year to year and almost 50 per cent of the annual total rainfall can occur within a single month. Most rainfall tends to occur in the summer months and significant events tend to be limited to one or two occurrences each year. The seasonal distribution of rainfall and potential evaporation is shown in Table 7-1 and Table 7-2, respectively. This shows that on average monthly rainfall is about one seventh of the monthly potential evaporation. Whilst the record shows that occasionally rainfall can exceed potential evaporation in very wet months, actual evaporation will closely match rainfall throughout the year and virtually all the rain that does fall will evaporate.

Table 7-1 Mean monthly rainfall (mm)

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Napperby	55	55	39	22	21	11	14	6	7	19	30	40	309
Alice Springs	41	43	31	17	18	13	15	9	8	21	29	37	282
Mine Site	48	73	68	30	11	5	6	1	1	3	35	32	314

Table 7-2 Mean monthly potential evaporation (mm)

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Alice Springs	271	221	210	159	112	87	97	134	178	230	238	259	2196
Mine Site	286	240	235	185	137	91	89	163	200	249	257	265	2396

7.3.3 Surface water drainage

Semi-arid regions such as the area in which the mine is located are typically characterised by conditions in which evaporation closely matches rainfall and virtually all rainfall evaporates during events resulting in almost no surface runoff. This general situation will alter if intense rainfall occurs. Therefore, the occurrence of surface runoff and flows within local creeks is likely to be infrequent and only occur during exceptional rainfall events, such as those associated with the occasional southward extension of a monsoon trough or periodic incursion of north-west cloud bands over the interior of the continent.

Kerosene Camp Creek is an ephemeral creek and flows through the centre of the mine site before joining with a major tributary three kilometres further to the north where after it eventually flows into Woodforde River. Minor tributaries of Kerosene Camp Creek occur upstream of the mine site between the processing site and the mine site and have a combined catchment area of approximately 19.5 km^2 (Figure 7-1). Nolans Creek is a major tributary of Kerosene Camp Creek and has a catchment area of approximately 26 km^2 upstream of the open pit. It flows adjacent to the eastern boundary of the proposed TSF and will pass between WRDs 2 and 6 where after it joins Kerosene Camp Creek (Figure 7-2).

The Woodforde River, into which Kerosene Camp Creek flows, passes through the western margins of the Ti Tree Basin aquifer which is about 20 kilometres downstream of the mine site (Figure 7-1). The aquifer at this location along the Woodforde River is about 60 m below ground level (~550 metres ASL) (NRETAS 2007) and is down gradient of the mine site.

The access road from the Stuart Highway to the mine site crosses the drainage paths from catchments on the upper slopes of the Yalyirimbi Range (Figure 7-3). Drainage continues to flow towards the Southern Basins and Lake Lewis 40 kilometres to the west of the Nolans site. Catchments upstream of the access road are relatively small, typically less than 3 km^2 with one catchment of about 12 km^2 located towards the eastern end of the access road.

The processing site also receives drainage from the upper slopes of the Yalyirimbi Range (Figure 7-2). Due to their small catchment area, channels tend to be ill-defined with runoff likely to be dispersed across the south facing hillslope before combining into distinct creeks which eventually drain into the Southern Basins and Lake Lewis 40 kilometres to the west. Catchments upstream of the processing plant are typically less than 1 km^2 in extent.

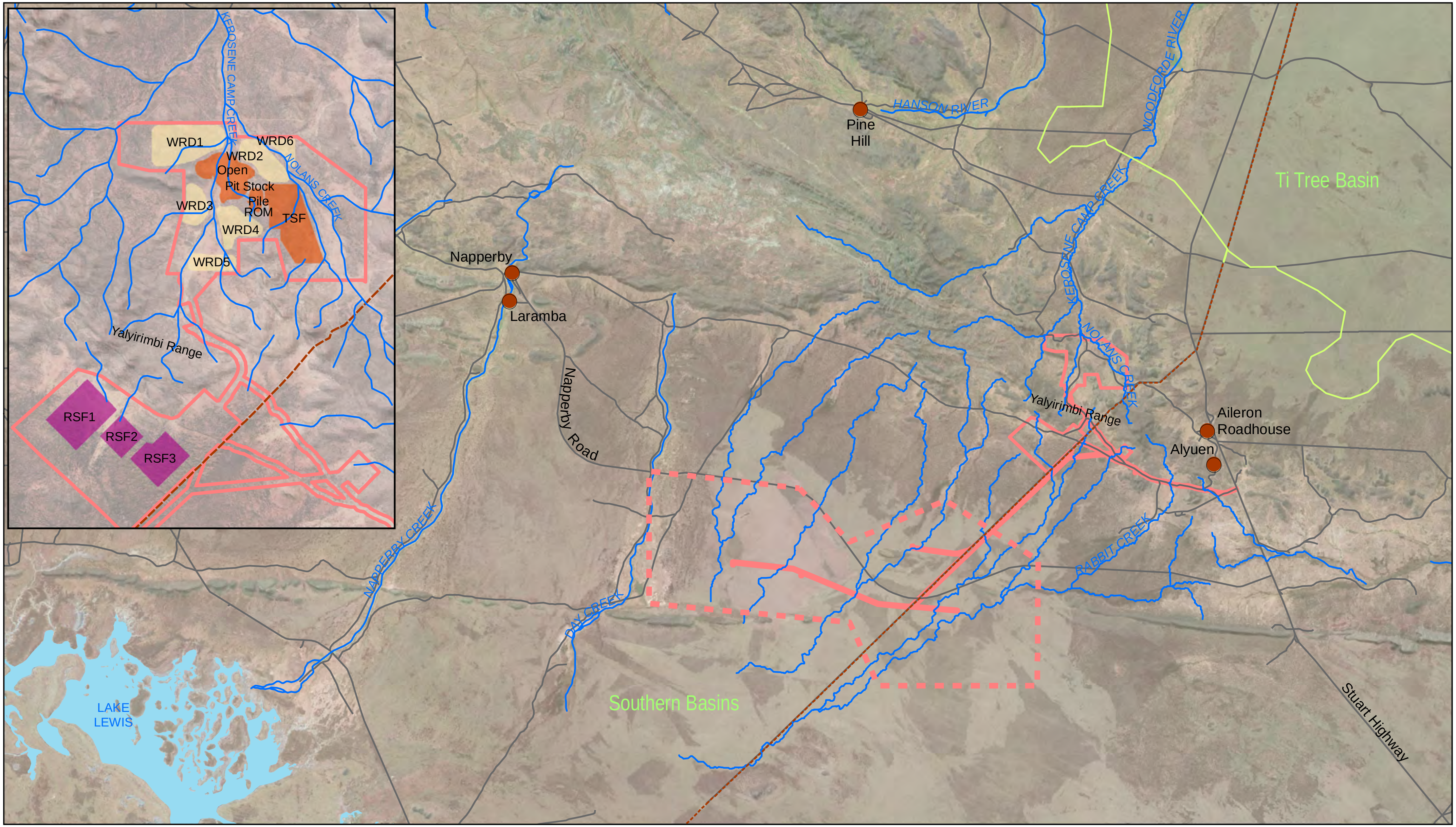
7.3.4 Surface water monitoring

Long-term gauging of flow in watercourses that traverse or flow close to the proposed mine site has been carried out at Arden Soak Bore on the Woodforde River. This gauge is located approximately 26 kilometres downstream of the mine site and includes the runoff from catchments at the mine site.

Flow records show that flow events are relatively infrequent with only 25 per cent of days during the 41-year record having a total daily flow greater than 3 Ml (arbitrarily selected discharge of 0.03 m^3/s) and thus even fewer days with larger flow volumes.

The occurrence of surface runoff is most likely in months during the summer season, December to March (refer Figure 7-4). Records at Arden Soak Bore suggest that only one or two flow events can be expected in most years. The maximum recorded flow at Arden Soak Bore (Figure 7-5) is 206 m^3/s (January 2010) during which flow was recorded over a period of just three days indicating the relatively ‘flash’ response and short duration of flow events for drainage systems in this region.

Anecdotal evidence suggests that surface runoff infiltrates to the alluvium of creek channels where after it will form shallow groundwater flow moving down gradient along the creek channel.



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0 2.5 5 7.5 10

Kilometres

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

N

LEGEND

- Outstations and Communities
- Groundwater basin boundary
- Gas pipeline
- Waterways
- Roads
- Project Areas
- Borefield Area
- Waterbodies

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Surface water drainage network

Figure 7-1

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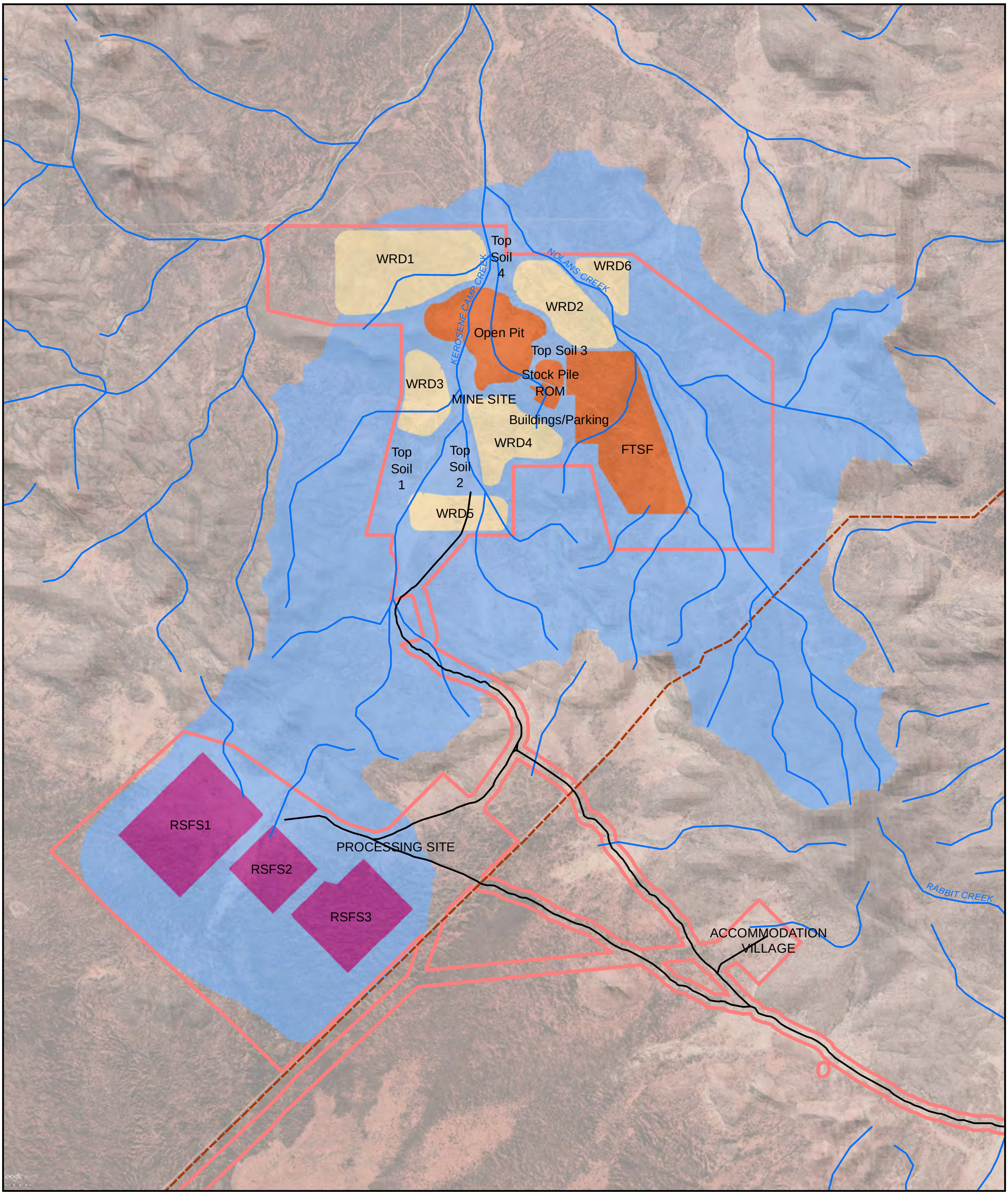
Level 5 66 Smith Street Darwin NT 0800 Australia **T** 61 8 8982 0100 **F** 61 8 8981 1075 **E** drwmail@ghd.com **W** www.ghd.com

Data source: GA - Roads, Placenames, Placenames, Lakes, Imagery (2015). ESRI - Shaded Relief (2009). ARL - Project Areas (2015). GHD - Waterways, Outstations and Communities (2016). Created by: CM



LEGEND

- Access Road
- Waterways
- Gas Pipeline
- Project Areas

Water Type

- Clean
- Ore Contact
- Process
- Sediment

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0 0.5 1 1.5 2

Kilometres

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

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Date | 13 Apr 2016

Surface drainage network at the mine site and processing site

Figure 7-2

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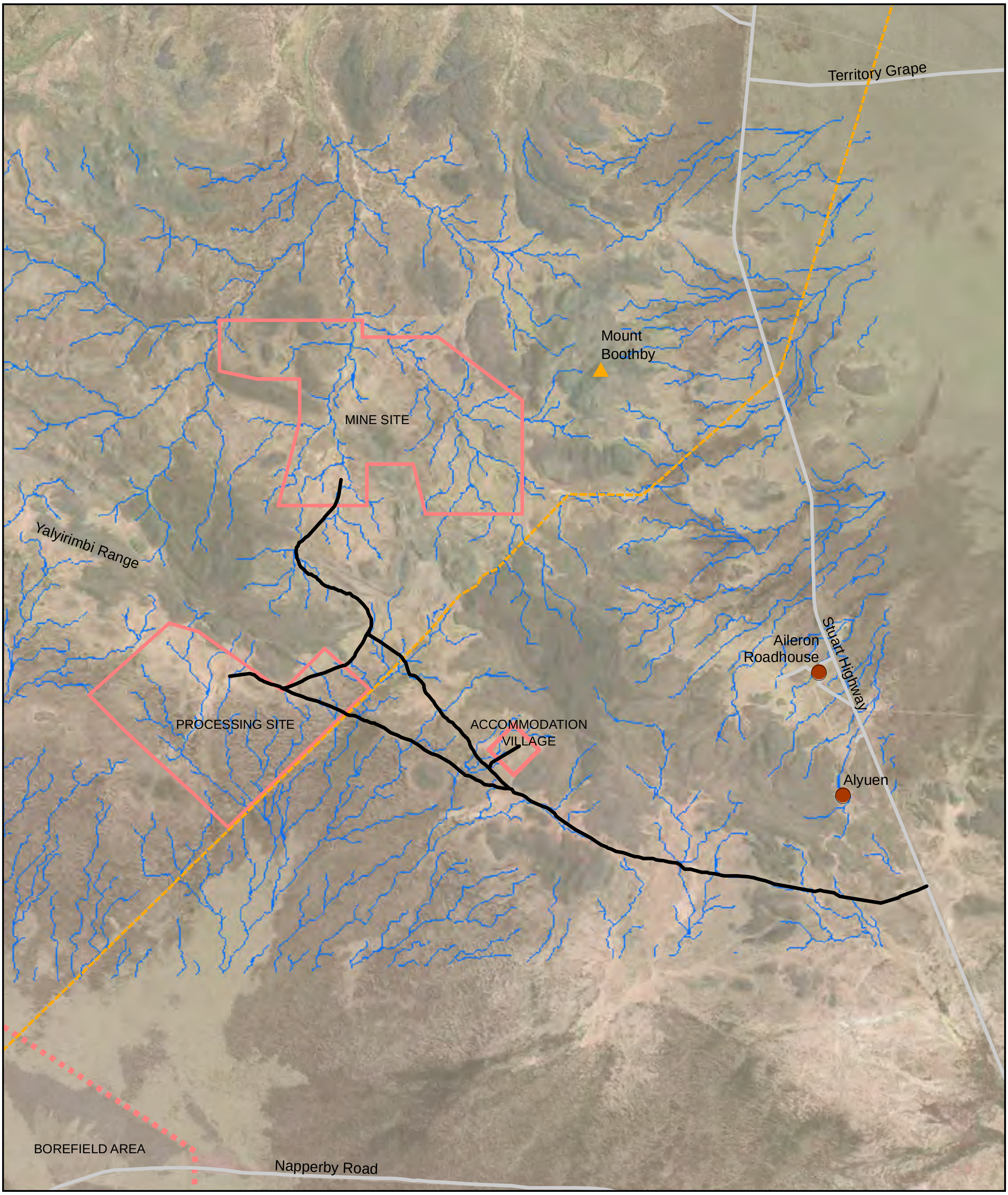
Level 5, 66 Smith Street Darwin NT 0800 Australia T 61 8 8982 0100 F 61 8 8981 1075 E drwmail@ghd.com W www.ghd.com

Data source: GA - Roads, Waterways, Placenames, Placenames, Lakes (2015). ESRI - Shaded Relief (2009). Google Earth Pro - Imagery (Date extracted: 11/02/2016). ARL - Project Areas (2015). GHD - XPRafts Model (2016). Created by: CM



LEGEND

- Mountain
- Outstations and Communities
- Roads
- Access Track
- Gas Pipeline
- Natural drainage
- Project Areas

1:125,000 @ A4

0 1 2 3 4

Kilometres

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

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Access road drainage network

Figure 7-3

G:\43\22301\GIS\Maps\4322301_575_AccessRoadNaturalDrainage.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: GA - Roads, Placenames, Placenames, Lakes, Images (2015). ESRI - Shaded Relief (2009). ARL - Project Areas (2015). GHD - Natural drainage (2016). Created by: CM

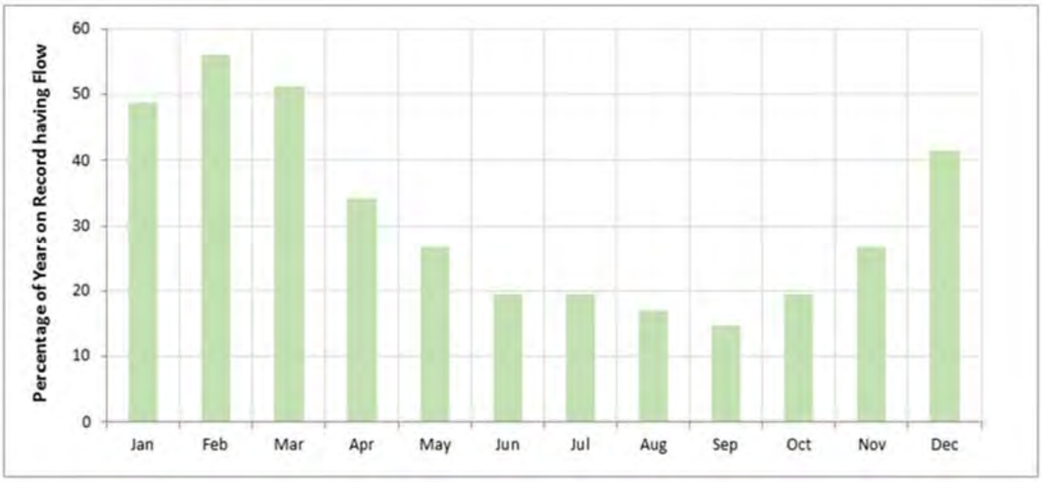


Figure 7-4 Occurrence of flow at Arden Soak Bore on Woodforde River

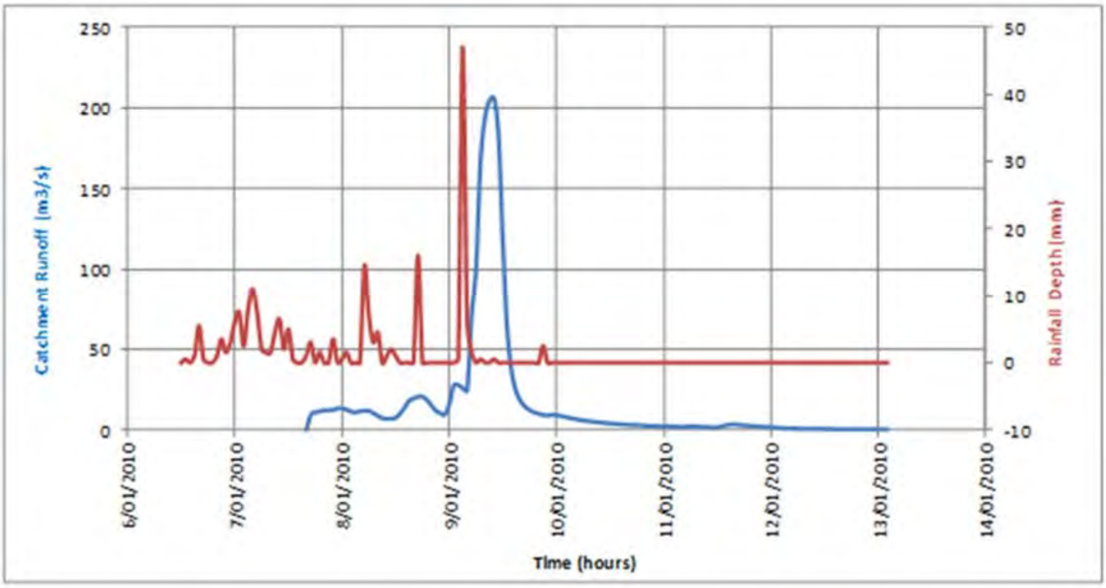


Figure 7-5 Maximum recorded flow at Arden Soak Bore on Woodforde River

7.3.5 Geomorphology

Creeks flowing through the mine site are generally straight with gentle bends and grades of approximately 1 in 400 (0.25 per cent).

The existing channel of Kerosene Camp Creek has bankfull widths in the order of 10 to 15 metres and depths in the range of 1 to 2 metres. The channel invert typically consists of a relatively featureless bed of sand with some gravel. In cross-section, the channel is symmetrical and relatively simplistic in form with limited evidence of features such as pools, bars or benches. Banks are composed of alluvially deposited sand and silt and are vegetated with low grasses and scattered shrubs and trees. Bedrock occasionally outcrops in the banks and bed providing some control on channel form and bed levels.

Nolans Creek is set within a terraced valley with the contemporary valley floor extending up to approximately 100 metres. The inset floodplains typically bound either side of the channel, with the surrounding terrace surfaces rising 1 to 2 metres above the floodplains. Based on bank exposures the floodplains are likely to be dominantly composed of silty sand. The floodplain surfaces are largely vegetated with low shrubs and are dissected by shallow flood channels.

7.3.6 Surface and groundwater interaction

The groundwater characteristics of the region within which the Nolans site is located are described in Chapter 8 of this EIS.

Regionally, the mine site is located near the southern margin of the Ti Tree Basin (Figure 7-1). Groundwater is approximately 15 metres below the ground surface at the mine site location. The processing plant is located on the northern margin of the Whitcherry Basin which is one of a series of interconnected basins termed the ‘Southern Basins’ that drain westward and toward Lake Lewis, 40 kilometres southwest of the processing plant (Figure 7-1). The Ti Tree and the Southern Basins are considered to connect at the eastern margin of the Southern Basins near the Stuart Highway in an area termed ‘The Margins’. The Margins area is considered to be a subtle groundwater divide with water flowing north of the divide to the Ti-Tree Basin and south of the divide to the Southern Basins. The Yalyirimbi Range ridgeline between the mine site and processing site is the surface water divide between the Ti Tree and Southern Basins.

The ephemeral nature of creeks indicates no sustained support of surface flow from groundwater. In addition, the large disparity between evaporation and rainfall throughout the year suggests that recharge of aquifers is limited to periods of intense rainfall which are infrequent (once or twice a year) and relatively short lived.

The local aquifer at the mine site is thought to approximately correspond to the geographical extent of the ore body which is surrounded by much lower permeability basement rocks that act as an aquitard (Appendix K). It is expected that, due to the porous nature of soils in the area and the surface outcropping of the ore (apatite), this local aquifer will be recharged directly from surface infiltration during infrequent rainfall events and by leakage through the overlying creek bed when Kerosene Camp Creek is flowing.

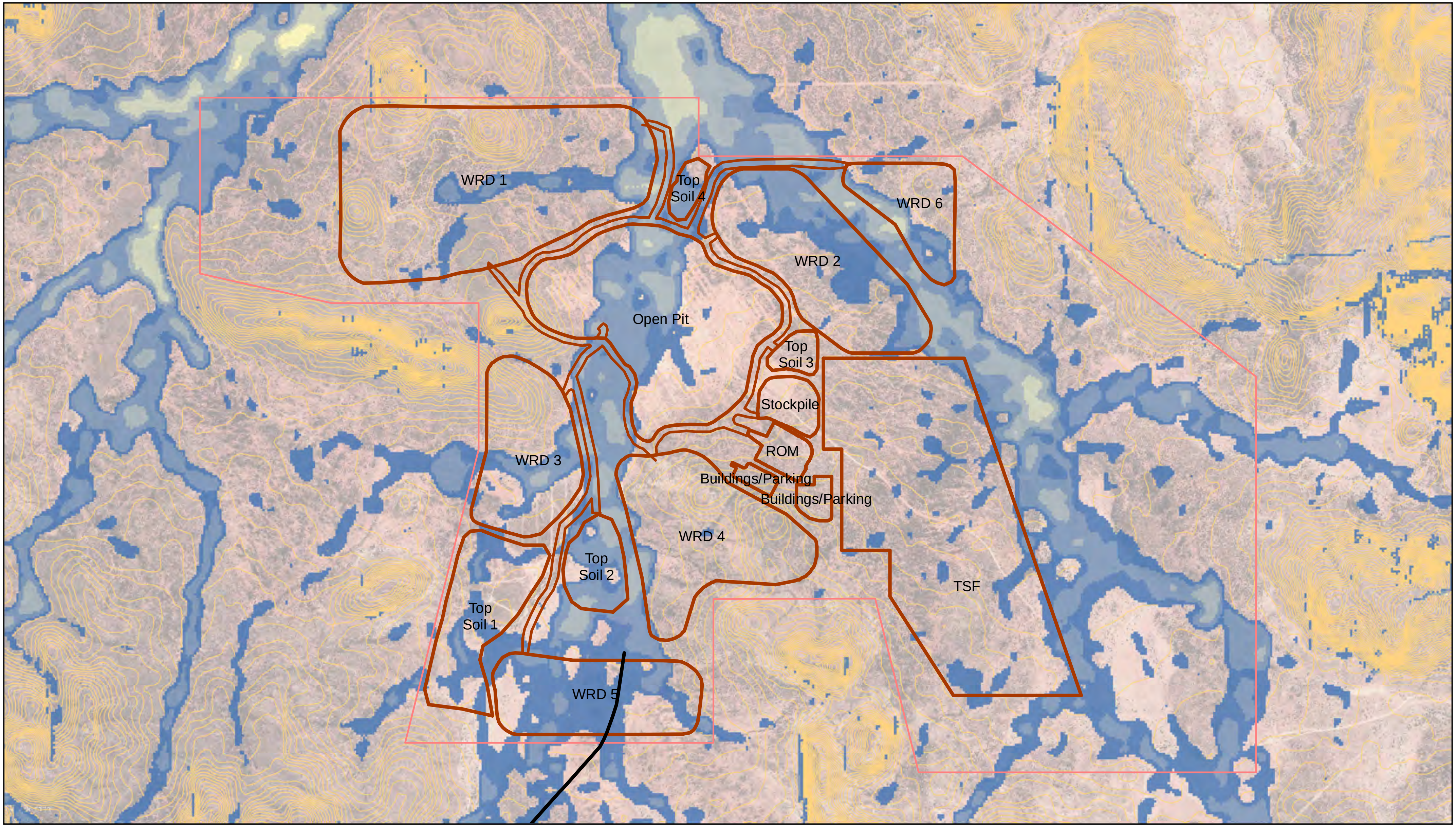
7.3.7 Flood risk

Flow events are infrequent and the probability of the mine site experiencing flood events with annual recurrence intervals of between 10 and 1,000 years during the 43-year LOM can be summarised as follows:

- 1 in 10-year ARI flood event has a 99 per cent probability of occurring during the LOM
- 1 in 50-year ARI flood event has a 58 per cent probability of occurring during the LOM
- 1 in 100-year ARI flood event has a 35 per cent probability of occurring during the LOM
- 1 in 1,000-year ARI flood event has a 4 percent probability of occurring during the LOM.

The lateral extent, depth, and velocity of flooding for existing site conditions (pre-mining) is shown in Figure 7-6 and Figure 7-7, and a summary of indicative flood depth and velocity at significant locations is provided in Table 7-3. Flood peak discharge along the two creeks flowing through the proposed mine site (Kerosene Camp Creek and Nolans Creek) has been obtained from hydrological modelling described in Appendix I.

Estimates of flood peak discharge assume a 4.5 hour storm rainfall event which is equivalent to the time of concentration for catchments draining to the downstream boundary of the proposed mine site. It is recognised that the critical storm duration will vary across the site and therefore more detailed modelling will be required during the design stage.



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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

Access Roads	Mine Site Boundary	1.0 - 1.5	2.5 - 3.0
Haul Roads	**Pre-Mining Flood Depth (m)**	1.5 - 2.0	3.0 - 3.5
2m Contours	0.0 - 0.5	2.0 - 2.5	4.0 - 4.5
Infrastructure	0.5 - 1.0		

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Flood depth for 1 in 1000 year ARI design storm event - pre-mining Figure 7-6

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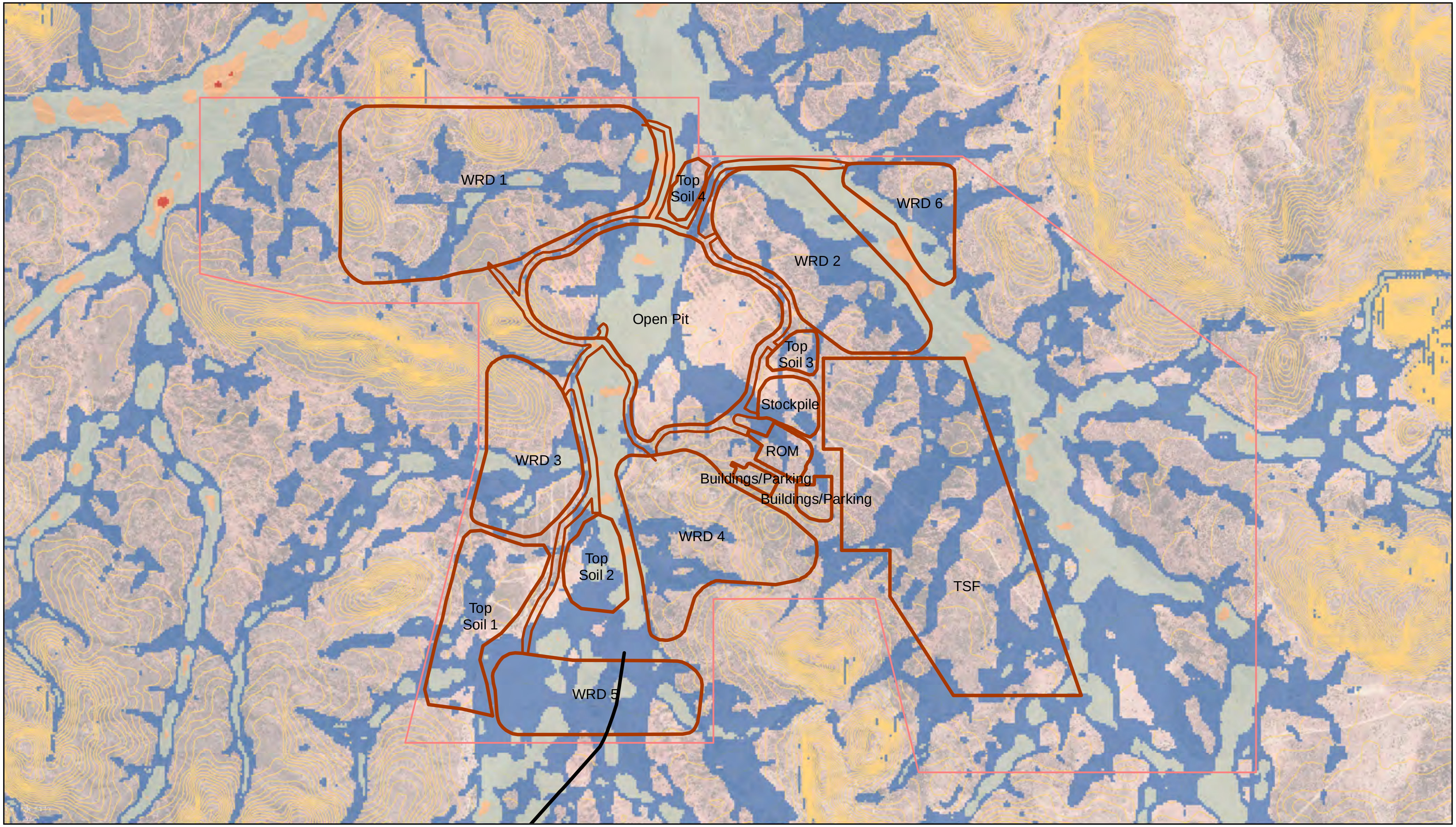
Level 5 66 Smith Street Darwin NT 0800 Australia T 61 8 8982 0100 F 61 8 8981 1075 E drwmail@ghd.com W www.ghd.com

Data source: Google Earth Pro - Imagery (Date extracted: 29/04/2015). ARL - Proposed Haul Roads, Existing Creek Channels, Proposed Infrastructure (2015). CSIRO - 2m Contours (derived from SRTM) (2015). GHD - Flood Data (2016). Created by: CM



1:35,000 @ A4

0 250 500 750 1,000

Metres

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

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LEGEND

Access Roads

Haul Roads

2m Contours

Proposed Infrastructure

Mine Site Boundary

Pre-Mining Flood Velocity (m/s)

0.0 - 0.5

0.5 - 1.0

1.0 - 1.5

1.5 - 2.0

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Flood velocity for 1 in 1000 year ARI design storm event - pre-mining Figure 7-7

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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 Haul Roads, Existing Creek Channels, Proposed Infrastructure (2015). CSIRO - 2m Contours (derived from SRTM) (2015). GHD - Flood Data (2016). Created by: CM

Table 7-3 Design flood characteristics – pre-mining

Creek	Location	Upstream Area (km^2)	1 in 1,000-year ARI – 4.5 hr flood event [a]	
			Velocity (m/s)	Depth (m)
Nolans	Upstream mine site boundary	26.3	0.9	1.3
Nolans	Downstream mine site boundary	28.2	0.6	1.3
Kerosene Camp	Upstream mine site boundary	12.3	0.3	0.2
Kerosene Camp	Proposed diversion inlet	20.4	0.8	1.0
Kerosene Camp	Downstream mine site boundary	25.8	0.7	1.6
Kerosene Camp	Downstream of confluence of Kerosene Camp Creek and Nolans Creek	58.7	0.7	1.7
Tributary of Kerosene Camp	Proposed diversion outlet	46.0	0.7	1.8

Notes: [a] storm duration corresponds to the time of concentration at mine site boundary

7.3.8 Water quality

The character of surface water quality is influenced by land use and the mineral composition of soils and near-surface geology. The absence of a sustained base flow contribution to watercourses is likely to limit the influence of deeper bedrock geology on surface water quality.

Baseline ambient water quality of surface water systems (when they flow) has been determined from the results of water monitoring. Surface water quality records are available from the DLRM water data portal. This data is limited to just two locations in the vicinity of the mine site, namely Arden Soak Bore (G0280010) which is on the Woodforde River 26 kilometres downstream of the mine site, and Allungra Waterhole (G0280004) which is on a different river system 42 kilometres to the east of the mine site. These records are limited to just a few individual samples taken in February and March 2011.

The available records include salinity, pH, dissolved oxygen, temperature and turbidity.

The water sampled in the Woodforde River was fresh but very turbid, neutral in pH and with sufficient dissolved oxygen to support aquatic life. Conditions at the mine site (which is a smaller catchment) may exhibit higher salinity and turbidity due to the lower volume of flow and thus its smaller dilution capacity.

7.3.9 Existing water users

Environmental water use is constrained by the sporadic nature of rainfall and surface runoff. Vegetation and fauna are either capable of surviving in between rainfall events or are able to access shallow groundwater. Depth to groundwater is generally greater than the reach of root systems, except along watercourses where the channel alluvium provides access to shallow groundwater, particularly along the Woodforde River downstream of the mine site.

Lake Lewis and its surrounds is a declared Site of Conservation Significance (SOCS) with a rating of National Significance. The processing site is located in the catchment of the Southern Basins, which drains toward Lake Lewis 40 kilometres to the south-west.

7.4 Project water balance

Water storage facilities should be designed to handle and control required inflows and outflows including unpredictable fluctuations due to exceptional storm inflow. Consideration of such inflows and outflows in a water balance will help identify storage requirements and minimise the risk of uncontrolled overflow and thus structural failure.

A monthly water balance has been carried out to identify whether the Nolans Project is likely to be in water deficit or surplus regarding its water supply requirements.

Available water resources will include water sourced from the borefield (located in the Southern Basins aquifer southwest of processing site), pit dewatering, tailings water that will be recycled from the TSF, and infrequent and short-lived water available from stormwater management ponds.

Open pit dewatering rates have been estimated by groundwater modelling which is reported in Chapter 8.

Project water demands (Figure 7-8) comprise the requirements for ore processing (crushing, beneficiation and processing plants), dust suppression along haul roads and at the ROM pad, together with potable water demands for the site.

7.4.1 Project water use

The overall site raw water demand is projected to peak at 4,777 ML/y. This includes a demand for process water of 4,418 ML/y, potable water 91.5 ML/y and dust suppression 267 ML/y.

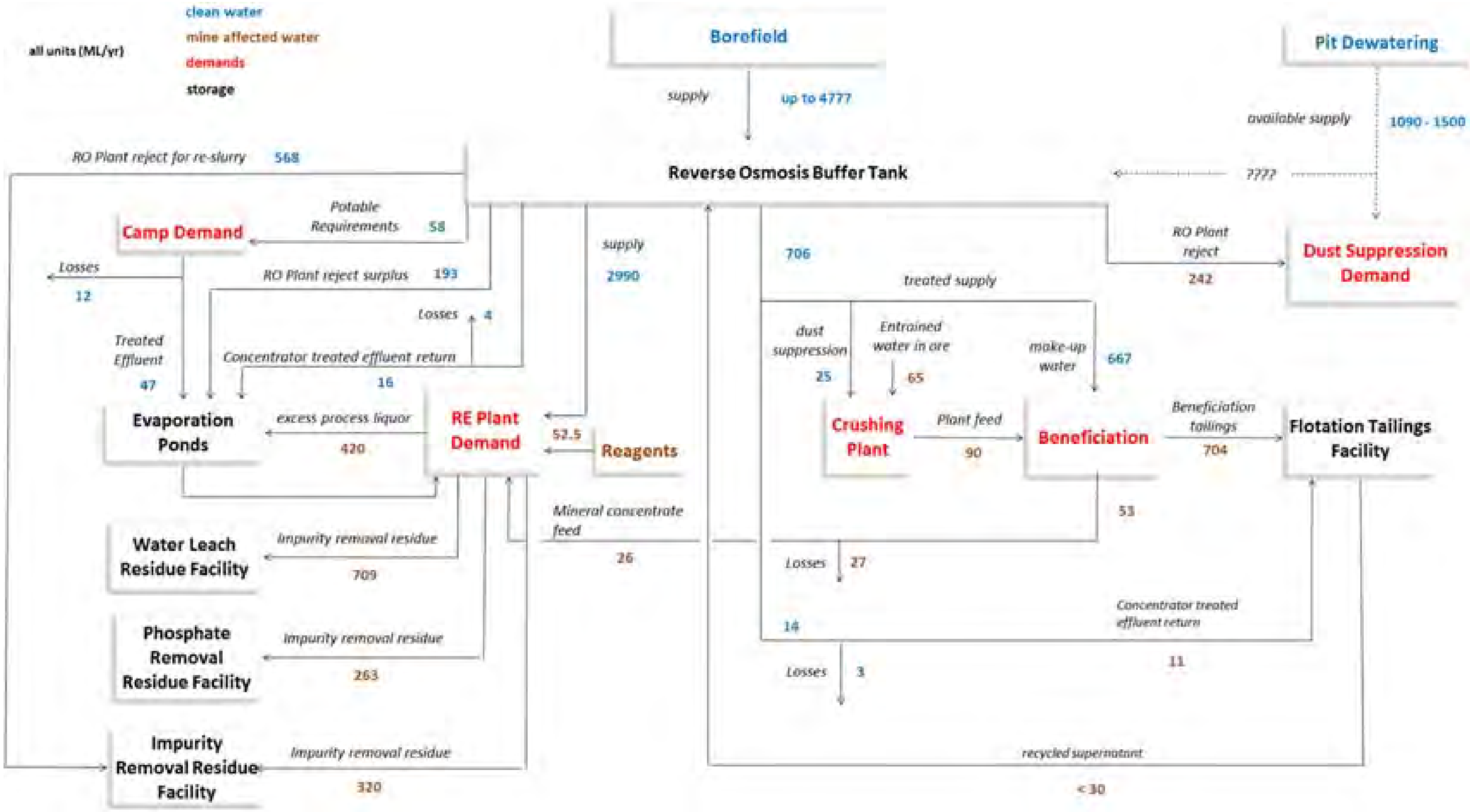


Figure 7-8 Schematic of project water demands (ML/yr) adapted from Lycopodium (2014)

The results of a mine site water balance are summarised in Table 7-4, based on the following:

- Seven mine development stages corresponding to the open pit development stages
- Monthly rainfall and evaporation comparable to conditions during an average year
- Estimation of recycled supernatant water from the TSF based on a slurry inflow of 0.45 Mtpa, which is assumed to correspond with mine development Stage 6 when the maximum quantity of material is mined. Quantities of recycled water for other mine development stages have been pro-rated from this maximum value by means of the relative quantity of mined material (Appendix D of Appendix I)
- Estimation of runoff within the open pit assumes a conservative rainfall loss of 90 percent from evaporation and seepage
- Groundwater inflow of up to 46 L/s depending on the pit water level (Appendix E of Appendix I)
- Pro-rating of the peak processing water demand (4,510 ML/yr) to provide estimates of water demand during other mine development stages. This has been achieved using estimates of the quantity of material mined in each development stage
- De-watering maintains a dry pit floor throughout the year, and
- Recycling of the water captured in sediment ponds at WRDs is assumed to be impractical due to the infrequent nature of surface runoff events.

The water balance for the processing site is excluded, as it comprises a closed system of incident rainfall 314 mm/yr and evaporation 2196 mm/yr only, with no transfers of water or catchment and groundwater inflow.

Table 7-4 Site water balance for average rainfall year

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 –	689	376	782	20	-2289	-2893	-328

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)
process demand							
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 {rainfall + groundwater inflow – losses} C Section 1.1.1 of Appendix I.

A comparison of the project process water demand with available on-site water resources indicates a potential surplus of water due to pit dewatering during the first four stages of mine development and a potential deficit in the supply of water demands thereafter.

Surplus water will be pumped to a turkey nest pond located at the mine site from where it will be recycled to augment project water supply, whilst deficits in demand will be met by groundwater supply from the borefield.

7.5 Assessment of potential impacts on surface water resources

7.5.1 Overview

The risk of an impact will occur if all three elements of a 'source – pathway – receptor' are present. In this instance the source – receptor of impact is

- Mine affected runoff from the mine site or processing site impacting on downstream receptors e.g. drainage lines or infrastructure e.g. access roads
- Upstream catchment flood water impacting on the mine site or processing site infrastructure or roads
- mine site or processing site construction impacting on normal flows or flood flows in downstream creeks and waterways (due to "removal" of catchment area of the mine from the normal/natural catchments)
- access road construction impacting on normal flows or flood flows across the landscape and in drainage channels.

In terms of surface runoff, the pathway can be:

- Sheet flow
- Channel flow
- Near-surface flow within the channel bed (groundwater pathways are discussed in Chapter 8).

Receptors may include:

- Third party infrastructure
- Water supplies
- Locations with environmental or heritage value
- Nolans site infrastructure

The level of risk posed to surface water resources by each source of impact was assessed using standard qualitative risk assessment procedures, which have been described in Chapter 5 and Appendix F. These risks are described in more detail below.

The elimination of risk is achieved by removing a source, pathway or receptor. If this proves impractical then a risk is managed by the implementation of project controls which are outlined below and dealt with in more detail in the water management sub plan contained within the Environmental Management Plan (Appendix X).

7.5.2 Separation of clean and mine affected water

Potential impact

Significant areas of catchment occur upstream of the mine site boundary comprising 16 km^2 within Kerosene Camp Creek catchment, 26 km^2 within Nolans Creek catchment and 16 km^2 within catchments upstream of the access road and processing plant (Figure 7-9). Due to natural flow paths, runoff that originates from upstream catchments will pass through the mine site and processing site and could therefore increase the volume of mine affected water.

If left undiverted, the open pit has the potential to capture 31 % of the runoff in Kerosene Camp Creek based on relative catchment areas upstream of the pit (19.5 km^2) and at the confluence of Kerosene Camp Creek with a major tributary of Kerosene Camp Creek (63 km^2) (Figure 7-9).

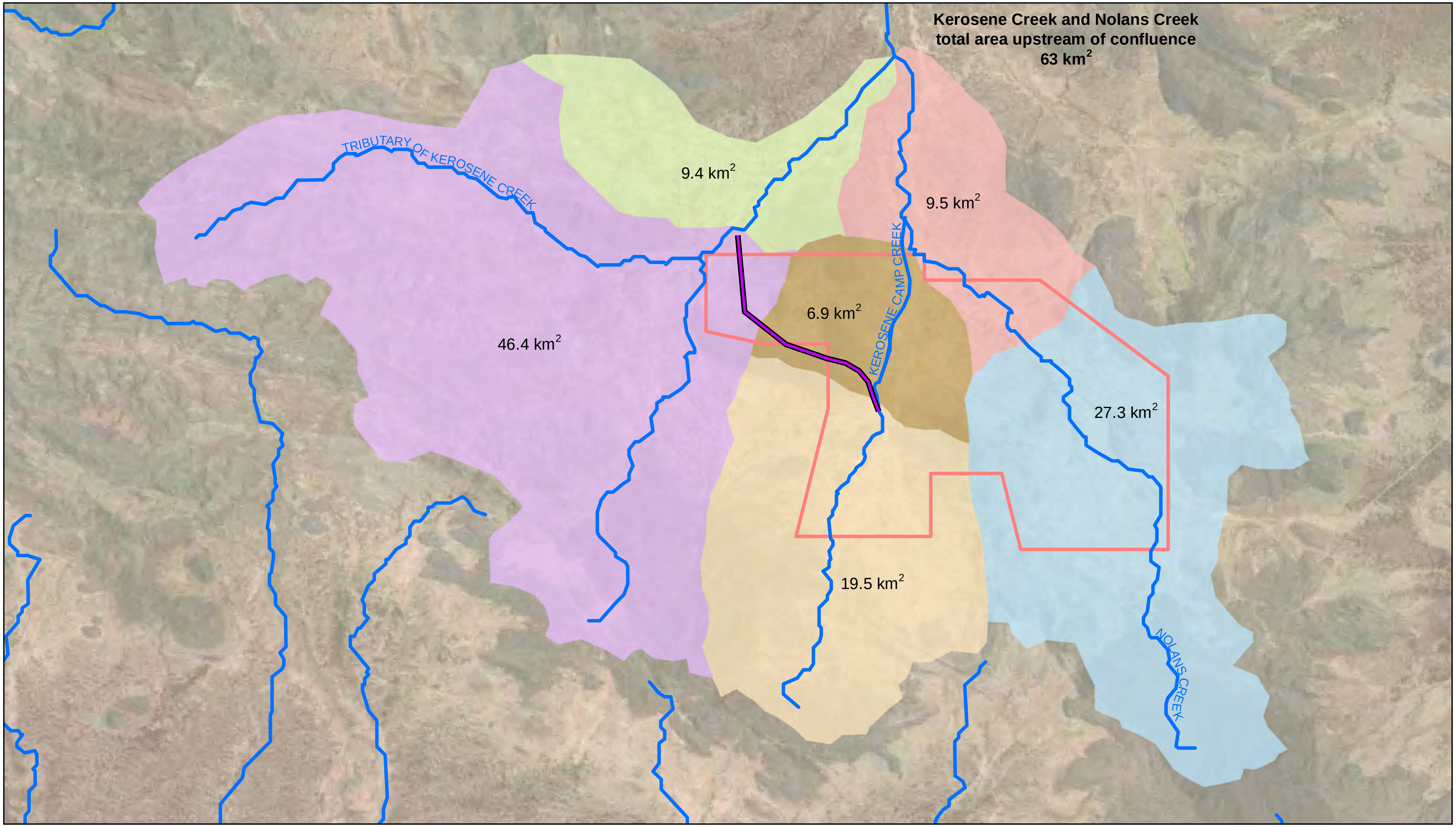
A proposed diversion of Kerosene Camp Creek will cause a change in the direction of flow within Kerosene Camp Creek. An options study (appended to Appendix A of Appendix I) suggests that this will cause an increase in water depth during a 100-year ARI flow event of 1.5 m immediately upstream of the diversion inlet and reduce the flow velocity and shear stress. Additional preliminary modelling suggests the water level upstream of the diversion inlet would increase by a further 0.2 m during a 1 in 1,000-year ARI flow event.

The Kerosene Camp Creek diversion outlet will also cause an increase of 30 percent in the catchment area contributing flow to a major tributary of Kerosene Camp Creek that will cause flows in this receiving watercourse to increase by a similar amount. The design study also suggests that the diverted flow will have flow energies and erosion and sediment transport potential similar to existing conditions in the receiving channel. As a result, the additional flow discharge from the diversion is not expected to have a significant impact on the morphology of the receiving channel (Appendix I).

Controls

Areas adjacent to the creek diversion will need to be protected against over-bank flow by means of a flood protection levee along the approach channel. The final longitudinal profile for the diversion channel will be designed to achieve flow conveyance and sediment transport in the approaches to the diversion that are close to existing conditions within Kerosene Camp Creek.

The diversion of clean water runoff around the processing site will be achieved by means of flood protection bunds and shallow drainage ditches. Conceptual designs are included in the Environmental Management Plan (Appendix X).



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0 500 1,000 1,500 2,000

Metres

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

N

LEGEND

- Diversion Channel
- Waterways
- Mine Site Boundary

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Kerosene Camp Creek diversion catchments

Figure 7-9

G:\43\22301\GIS\Maps\4322301_572_NolansDiversion.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

7.5.3 Sedimentation and soil erosion

Potential impact

Vegetation clearing and site establishment, including construction of roads will occur during construction of the project including:

- site preparation and topsoil stripping
- excavation of WRD footprints
- creation of top soil stores
- establishment of haul roads and access roads, and construction of cross drainage structures such as culverts and floodways
- construction of processing facilities including tailings and residual storage, and
- construction of the accommodation village.

The construction of project infrastructure and use of heavy machinery in and around existing drainage channels may degrade the structural integrity of the channel edge or deposit material within the channel, thereby impeding or altering existing waterways.

Depending on the carrying capacity of the stream, sediments may be deposited or bank erosion may occur to increase the sediment load in the water to its "carrying capacity".

Whilst creek beds are generally mobile due to the unconsolidated nature of bed material, the relatively shallow gradient of longitudinal profiles limits creek flow velocities to generally less than 1.5 m/s during a 1 in 1,000-year ARI event (Appendix I). This limits the potential for erosion during extreme flood events. Small areas between mine infrastructure have larger gradients and therefore have greater potential for erosion.

Controls

Controls to reduce overland flow-induced erosion are set out in the Environmental Management Plan (Appendix X) and include:

- contouring, such as the creation of a series of benches, swales, furrows or irregularities that cause the precipitation to pond, and infiltrate or evaporate rather than translate into runoff
- construction of water containment structures to hold sediment laden run off and prevent its release to the downstream environment
- vegetation, once established, is probably the most cost-effective erosion control measure.

7.5.4 Construction of linear infrastructure and cross drainage structures

Potential impact

Haul roads and access roads will cross a large number of minor creeks with small upstream catchments.

Construction activities have the potential to cause a reduction in the existing capacity of channels or an increase in channel bed gradient. This could lead to a localised increase in flow velocity during rainfall events, leading to the potential for erosion of creek beds.

Conversely, if channel widths are increased or channel bed gradients reduced this could result in a reduction in the velocity of flow and an increased potential for the deposition of sediment.

To prevent problems associated with erosion or sedimentation at road crossings, changes to the drainage path and flow conveyance capacity of creeks will be minimised where practicable.

Preliminary flood modelling of catchments upstream of proposed haul roads suggests that flood depths and velocities during a 1 in 1,000-year ARI event will not exceed 0.5 m and 1.0 m/s, respectively. Flood depths and flood velocities during more frequent storm events such as a 20-year ARI event would be significantly less.

Controls

Given the limited depth and likely duration of flood flows at roads it is likely that floodways consisting of a localised depression in the elevation of the road formation and reinforcement of the road verge to facilitate the spillage of flow across the depressed section of road; will be the most appropriate method of 'bridging' creeks.

Where creeks are wide, the gradient of creek banks steep, or roads are susceptible to erosion, it will be necessary to use culverts instead of floodways.

7.5.5 Flooding

Potential impact

Preliminary flood modelling of the Nolans site and its upstream catchments has been undertaken to provide an estimate of flood levels and velocity during a 1 in 1,000-year 4.5 hr ARI storm event. Changes in flood levels and flood velocities as a result of mine development have also been assessed (Appendix I) and are summarised for significant locations across the mine site in Table 7-5.

Table 7-5 Design flood characteristics – post-mining

Creek	Location	1 in 1,000-year ARI – 4.5 hr flood event [a]			
		Velocity (m/s)	Depth (m)	Velocity Change [b] (m/s)	Afflux [b] (m)
Nolans	upstream of mine lease boundary	0.9	1.4	0.0	+0.1
Nolans	downstream of mine lease boundary	0.6	1.4	0.0	+0.1
Kerosene Camp	upstream of mine lease boundary	0.2	0.4	-0.1	+0.1
Kerosene Camp	Upstream of proposed diversion inlet	0.3	1.7	-0.5	+0.7
Kerosene Camp	downstream of mine lease boundary	0.5	1.1	-0.2	-0.5
Kerosene Camp	downstream of confluence of Kerosene Camp Creek and Nolans Creek	0.6	1.3	-0.1	-0.4

Notes: [a] storm duration corresponds to the time of concentration at mine site boundary [b] change from pre-mining conditions

Nolans Creek flows along what will be the eastern boundary of the TSF and between the proposed locations for WRDs 2 and 6. The location of Nolans Creek in close proximity to mine infrastructure creates the potential for flooding and erosion. However, due to the shallow gradient of the creek and narrowing of the Nolans Creek floodplain due the WRDs, modelling suggests only a small flood level afflux of 0.1 m and no significant increase in flood flow velocity.

Kerosene Camp Creek enters the mine site adjacent to the proposed WRD 5, and proposed top soil stores in this area further impinge on the Kerosene Camp Creek. However, gradients in this area are relatively shallow and mine development is predicted to cause a small flood level afflux upstream of the mine site boundary of 0.1 m and an insignificant decrease in flood velocity of 0.1 m/s.

The proposed creek diversion will cause an abrupt change in the direction of Kerosene Camp Creek that will result in flow depth immediately upstream of the diversion inlet of about 1.7 m and a slowing of flood water flow by about 0.5 m/s during a 1 in 1,000-year ARI event (for more information see the Diversionreport at Appendix A of Appendix I). This will increase the potential for localised over-bank flooding and spillage from the diversion into the open pit and possibly sedimentation problems upstream of the diversion inlet.

Runoff generated from areas between the open pit, processing site and WRDs represents an additional potential source of water ingress to the open pit with typical flood depths of up to 0.2 m and small localised areas where flood depths reach 0.75 m, and velocities of up to 0.5 m/s.

Controls

The positioning and design of mine infrastructure will take account of the risk of flooding and erosion along existing watercourses and will either position infrastructure outside the 1 in 1,000-year ARI flood extent; or incorporate flood protection measures into flood prone areas. Flood protection measures will include:

- A flood protection levee constructed around the perimeter of the open pit rim to height of 1 m
- A flood protection levee in the approaches to the Kerosene Camp Creek to be constructed to a minimum height of about 2 m and profiling of the diversion inlet to equalise its velocity with that of the existing upstream natural channel
- Provide rock protection to the eastern external embankment of the TSF where flood velocities of to 0.5 m/s can be expected, along the toe of WRDs 2 and 6 adjacent to Nolans Creek (velocities of up to 1.5 m/s), and along the toe of WRDs 3 and 4 (velocities of up to 1 m/s) and WRD 5 and the neighbouring soil store (velocities of up to 2 m/s), and
- Incorporate drains along the western toe of WRD 3, along the southern toe of WRDs 4 and 5, and around the northern, western and southern sides of the TSF, to prevent ingress of runoff from adjacent catchments.

Conceptual designs of water management controls are included in the Environmental Management Plan (Appendix X).

7.5.6 Contaminated water

Contaminated water (by contact with ore and waste rock) will be generated by activities involving the extraction of ore (pit dewatering), its subsequent processing at the mine site (tailings from crushing and beneficiating the ore) and processing site (residue streams), and possibly during hauling of material to WRDs.

Potential impacts - open pit

The open pit will receive groundwater flow during excavation along with incident rainfall, and pit dewatering will be required to maintain dry working conditions. During the first development stage the pit void is at its smallest and the risk of pit overflow is highest should dewatering activities cease. A void space in excess of 4 Mm^3 will be achieved relatively quickly towards the end of stage one and would exceed the average annual volume of inflow from groundwater and incident rainfall.

In addition to the low risk of pit overflow, the low sulfur content, generally low metal toxicant content and low metal and salt leachability of the mined material, further limits the risk of acid mine drainage at the mine site (refer Appendix L of this EIS).

Potential impacts - waste rock dumps

WRDs will occupy a large proportion (590 ha) of the mine site area and will rise to a height of around 50 m. The material to be stored is largely non-acid forming (Appendix L). Detail of the likely water retention capacity of dumps is not available, however given the height and potential void space of stored material, the water retention is likely to be comparable with extreme (1 in 100-year ARI) storm rainfall events (depth of 295 mm) and annual average rainfall (depth of 310 mm). Therefore, the majority of incident rainfall over WRDs will infiltrate and result in negligible surface runoff or return of seepage to the ground surface.

Depending on the properties of material used in the base of the WRDs infiltrating water within the dumps will eventually seep into the underlying ground where it will follow prevailing hydraulic gradients. Following excavation of the pit void and implementation of dewatering activities, hydraulic gradients within the mine site are likely to be directed towards the open pit thereby reducing the potential for migration of mine-affected water to groundwater systems beyond the mine site.

Potential impacts - tailings and residue storage facilities

Due to the prevailing topography of the mine site, uncontrolled overflow from the TSF, should it occur; would discharge contaminated water into Nolans Creek where after, depending on the rate of overflow and the amount and flow of water within Nolans Creek, it could potentially reach the downstream Woodforde River system and the Ti Tree Basin.

Uncontrolled overflow from RSFs at the processing site, should it occur, would enter multiple small watercourses that flow southwards towards the Southern Basins and eventually the project's borefield water supply.

Climatic conditions that could cause overflow conditions to occur are also likely to result in the generation of flow within downstream creeks. Flow records for the Woodforde River suggest that during exceptional rainfall events surface flow can persist for at least one day. Due to the smaller extent of headwater catchments upstream of the mine and processing sites, the duration of flow in those local creeks is likely to be much shorter. Even so, assuming a moderate flood flow velocity of 0.5 m/s, it is likely to provide sufficient time for contaminated water to reach:

- The tributary of Kerosene Camp Creek (11 kilometres and 6 hours travel time) downstream of the TSF, or
- The edge of the Southern Basins area (10 kilometres and 5.5 hours travel time) downstream of the RSFs.

The migration of contaminated water beyond these distances would take more than one day and would be exposed to high levels of dilution by the ever increasing runoff volume from surrounding catchments.

Should overflow from tailings and residue storage facilities occur during dry conditions then contaminated outflow would seep into the shallow alluvium of adjacent local creeks. Anecdotal evidence suggests that subsurface flow occurs within the alluvium of creeks and this could presumably provide a path for the dispersion of contaminants.

Topographic gradients to the north of the mine site are about 0.2 percent whilst those to the south of the processing site are slightly steeper at 0.3 percent. Thus, an approximate estimate of subsurface flow velocity within the sandy creek beds (hydraulic conductivity 0.001 m/s) is in the region of 100 metres per year and the travel time to reach the tributary of Kerosene Camp Creek and the Southern Basins is therefore in excess of 100 years.

Controls

The mine site lies in the headwaters of the Woodforde River drainage system that flows across the western extension of the Ti Tree Basin. The processing site lies in the headwaters of the Southern Basins and the project's water supply borefield. For this reason, the storage capacity of TSF and RSFs will maintain a negative water balance (i.e. evaporation exceeding water inputs).

The TSF and RSFs will have a design storage capacity that is able to contain a 1 in 100-year ARI average annual rainfall whilst retaining sufficient additional freeboard to accommodate a probable maximum precipitation (PMP) 72-hour storm rainfall event. Water balances have shown that the accumulation of supernatant water can be controlled by natural evaporation, given this design storage capacity.

The storage facilities will also have maximum reporting levels above which water levels will invoke emergency measures to prevent overflow. In addition to evaporation, the supernatant water accumulating in the TSF will be controlled by recycling.

Due to adverse water quality the recycling of supernatant water is not permissible from the RSFs, these being the Water Leach Residue, Phosphate Residue and Impurity Removal Residue facilities.

Additionally, all storage facilities will have low permeability liners and leakage collection systems to reduce the risk of seepage to groundwater.

WRDs will be constructed with an inward sloping top and inward sloping mid-slope bench to trap incident rainfall and promote seepage to internal water storage. Given the relatively high height (50 m) of WRDs and low annual rainfall it is unlikely that internal pore spaces of the dump will become fully saturated where seepage emerging from its base would match infiltration at its surface.

Sediment ponds will be used to capture surface runoff from all mine affected areas to promote evaporation and seepage to ground.

The open pit will require dewatering to allow dry working conditions throughout its operation. Inflow from groundwater, and to a lesser degree incident rainfall, will be pumped to an on-site storage pond for recycling to the concentrator, processing site and/or dust suppression.

Dewatering of the open pit will cause a local drawdown of groundwater levels in the surrounding area. This will cause any seepage of surface water from WRDs and other areas of the mine site to migrate towards the pit, thereby reducing the risk of potential impact on the surface water or groundwater of areas beyond the zone of groundwater drawdown (i.e. more or less coincident with the mine site boundary).

The transfer pipeline between the mine site and processing site will be HDPE. The pipeline will run above ground within a bunded corridor. In the event of leaks or pipe failure, slurry will be captured within the bunded corridor and within event ponds located at significant low points along the eight-kilometre alignment. Specific details of event pond sizing and tiered bund levels will be considered during detailed design.

Additional information

A Failure Impact Assessment study (refer to Appendix J) was undertaken for the TSF to establish the potential risk to downstream residents from a hypothetical dam-break scenario. The risk is specified by a consequence category based on the concept of Population at Risk (PAR) and Potential Lives Lost (PLL).

PAR is the number of people expected to be within the failure impact zone in the event of a dam failure, including both a ‘Sunny Day Failure’ (pipe failure with no warning and dry downstream creeks) and ‘Flood Failure’ (breach failure with warning and flow in downstream creeks equivalent to a 1 in 100-year ARI event). At risk is defined as 300 mm of flooding within occupied buildings.

The assessment of PAR and PLL considered the following locations:

- Ti Tree, Waste Transfer Station,
- Pmara Jutunta community, water treatment station.

The assessment excluded site personnel within the model domain. The Stuart Highway is not shown to be inundated by a dam break and road users are therefore not considered to be at risk. Additionally, due to the remoteness of the region, small access tracks and dirt trails within the model domain were assumed unoccupied.

Neither of the above-mentioned occupied locations were shown to be inundated by a dam break flood involving the Sunny Day Failure scenario. The incremental PAR, as caused by a Flood Failure scenario in addition to that caused by natural flooding, is estimated to be less than one. Because the PAR is less than one, there is zero PLL.

The assessment of a consequence category under Australian National Committee on Large Dams (ANCOLD) Consequence Guidelines (2012a) is based on PAR and severity of damages criteria. Knight Piésold (2014) previously assessed the ‘severity of damage and loss’ for the TSF as having a worst-case impact of ‘High’.

Therefore, in the context of a PAR of less than one and a severity of damage and loss of medium, the appropriate ANCOLD consequence category for the TSF is ‘Low’.

7.6 Mitigation and monitoring

7.6.1 Mitigation

In addition to the control measures described above in section 7.5, the following administrative controls will be included:

- A water management plan (included in Appendix X) will be implemented including measures to manage flood and stormwater related issues such as:
  - Appropriate consideration of surface water flow in design, placement of infrastructure and construction
  - Proposals to capture surface runoff to small dams for monitoring/sediment control prior to release or recycle
  - Layout of construction ancillary facilities to avoid flood risk areas

  - Amenities and equipment would be located outside high flood hazard areas
  - The extent of works located in high flood risk areas
  - Diversion of overland flow either through or around work areas in a controlled manner
  - Runoff from disturbed areas would be diverted into sediment ponds and not discharged into the natural environment
  - Construction programme will be staged to occur in dry season;
  - Monitoring weather conditions and staging works to avoid periods of heavy rain
  - Developing flood emergency response procedures to remove temporary works during periods of heavy rainfall.
  - Progressive rehabilitation of WRDs to minimise exposed material and dust generation.
- Selection of appropriate ANCOLD risk category and adherence to relevant design standards for the provision of adequate storage capacity and freeboard allowance
- Embankment piezometers and survey pins, regular dam inspections
- Adherence to prescribed maximum operating level and retention of freeboard
- Monitoring program for phreatic levels within Embankment
- Biannual geotechnical inspection of TSF Embankment
- Procedures for spill events and tailings failure or overtopping, including:
  - Above ground pipeline within a bunded corridor
  - Processing plant notification of disruption to flow
  - Flow meters
  - Pressure sensors
  - Shift based visual inspections
  - Design - spray deflectors on welded joints
- Fire and emergency management procedures
- Establish maintenance procedures to ensure all water management equipment is installed and functional.
- An erosion and sediment control plan will be implemented prior to construction including:
  - Use of buffer zones, sediment fences and sediment ponds to arrest the transport of water borne sediment from the site
  - Progressive stabilisation of cleared land as activities are completed, to limit continued exposure of bare soils.
  - Rising stage samplers and gauging stations would be installed and maintained in creeks in and around the mine site to monitor surface flows and water quality in creeks.

7.6.2 Surface water monitoring

Surface water monitoring locations have been selected to meet baseline and ongoing monitoring requirements for the life of the operation and during closure. Details of surface water and water quality monitoring are provided in the Environmental Management Plan (Appendix X).

Surface water monitoring

Surface water monitoring sites for level and water quality will be located along Kerosene Camp Creek, Nolans Creek and headwater tributaries of the Southern Basins. Monitoring will incorporate existing gauges which includes rising stage surface water sampling points and water level gauges.

Bank stabilisation may be required at certain sites; however, the installation of low flow weirs is not recommended. It is considered that the beds at the sites, whilst mobile, provide a relatively consistent cross-section, whereas introducing a low flow structure in the channel may propagate change to the cross-sections through undercutting or sedimentation.

Theoretical rating curves would be required for the channel reaches at each of the surface water monitoring sites to enable conversion of the measured water depths to flow rates established through topographical surveys of the channel reaches and hydraulic modelling. Flow (current) gauging would be undertaken (if practical) to further calibrate the theoretical rating curves. Additional survey may be required, as needed, to establish if there has been any significant change to the channel cross section and/or morphology.

Sediment monitoring

Due to the relatively infrequent nature of streamflow events, sediment sampling would be undertaken to augment water quality sampling. Accumulation of radionuclides, rare earth elements, and other elements in the sediment would provide an indicator of surface water quality. Contaminant progression would be assessed through the distribution and dissipation/accumulation of such elements within the vicinity of and downstream of the mine site and processing site.

The sediment sampling procedure is provided within the Environmental Management Plan (Appendix X) and will include locations along Kerosene Camp Creek and Nolans Creek.

Sediment sampling will be undertaken annually throughout the life of the Project and into closure.

Shallow groundwater monitoring

Nested groundwater monitoring bores will be installed at key locations coinciding with proposed site infrastructure which is identified as a potential source of contamination. In addition, some background monitoring bores will be established. Further details are provided in the Environmental Management Plan (Appendix X).

08

Groundwater

8. Groundwater

8.1 Introduction

A detailed groundwater impact assessment report is provided in Appendix K of this EIS and an acid, metalliferous or saline drainage (AMD) assessment and management plan is provided in Appendix L.

Section 5.3 of the TOR for the preparation of an environmental impact assessment issued by the NT EPA for the project provided the following environmental objectives in relation to groundwater resources:

> *Proposed extraction of water will be within the sustainable limit of the aquifer or water supply to fulfil the Project needs over the predicted life-of-mine, without causing adverse environmental or social impacts.*
>
> *Water resources will be protected both now and in the future, such that ecological health and land uses, and the health, welfare and amenity of people are maintained.*

This chapter addresses the potential impacts of the project on groundwater resources, including the risk of AMD generation and the potential impact of groundwater extraction from the borefield. This chapter also considers the cumulative effects of extraction of groundwater from the mine site during operation and beyond closure as required in the TOR for the project.

8.2 Methodology

A summary of the approach and limitations to the groundwater impact assessment in the study area is summarised below and more detail is provided in Appendix K.

A hydrogeological investigation was undertaken on the Nolans Project using inputs from:

- previous studies on the Ti Tree Basin
- field studies at the mine site and
- field studies of the Southern Basins and Margins Area.

A dataset was developed from mineral exploration drill holes and investigation water bores. Of these, 75 water bores were drilled specifically as part of the Nolans Project.

A numerical groundwater flow model was developed based on these hydrogeological investigations. This was calibrated to steady state observed conditions and used to predict future conditions over time. This model provides the following outcomes:

- An estimate of future conditions
- Potential impacts and a quantification of the key impacts at key locations across the study area under the influence of the project operating conditions and under closure conditions
- Conceptual flows which consider:
  - Boundary conditions
  - Recharge
  - Evapotranspiration and
  - Groundwater extraction.

Modelled impacts to groundwater availability are considered from the perspective of groundwater flows (volumes over time), groundwater elevations (heads), groundwater flow direction and groundwater drawdown. In addition, the modelled impacts are considered in terms of impacts to groundwater chemistry and quality.

A desktop review of historical geochemical data and detailed geochemical analysis was undertaken to characterise waste rock and ore in terms of hazardous material and potential to develop AMD at the Nolans mine site.

A summary of the approach and limitation to the AMD assessment in the study area is summarised below and more detail is provided in Appendix L.

To gain an understanding of the relative rate of acid production and neutralisation over time as well as the mobility of metals in leachate testing the following key tasks were undertaken:

- Static AMD testing has been carried out on 200 samples (Stage 1) of potential waste rock and
- Splits from 25 of the Stage 1 samples were selected from each of the major rock types and from samples showing the highest indication of AMD risk as well as generally representative samples.

8.3 Existing environment

The following sections describe the groundwater resources identified in the study area and discuss the relative value of these resources in the local and regional context.

8.3.1 Extent of hydrogeological study area

The study area (Figure 8-1) is defined as covering the following four key groundwater areas (from north to south):

- The Ti Tree Basin
- Nolans mine site and surrounding fractured rock aquifer/basement
- The area referred to collectively as the Southern Basins
- The area where the Ti Tree Basin borders or abuts the Southern Basins which is referred to as The Margins.

The study area measures approximately 200 km east to west and 125 km north to south, and occupies a total of 19,000 km^2. In this report, these groundwater areas are collectively referred to as the groundwater system.

8.3.2 Topography

The topography of the study area is dominated by a flat plain, ranging from approximately 650 m AHD to 570 m AHD (over 120 km heading west) in the Southern Basins and from 650 m AHD to 505 m AHD (over 85 km heading north east) in the Ti Tree Basin. Above this plain, the Hann Range and Reaphook Hills rise up to approximately 150 m, and peaks of the Reynolds Range and Yalyirimbi Range up to almost 500 m above the plain

8.3.3 Study area climate

The study area climate consists of low rainfall (refer Appendix K) and high summer maximum temperatures (average of 37°C) and low minimum winter temperatures (average 6°C), typical of central Australian arid climates.

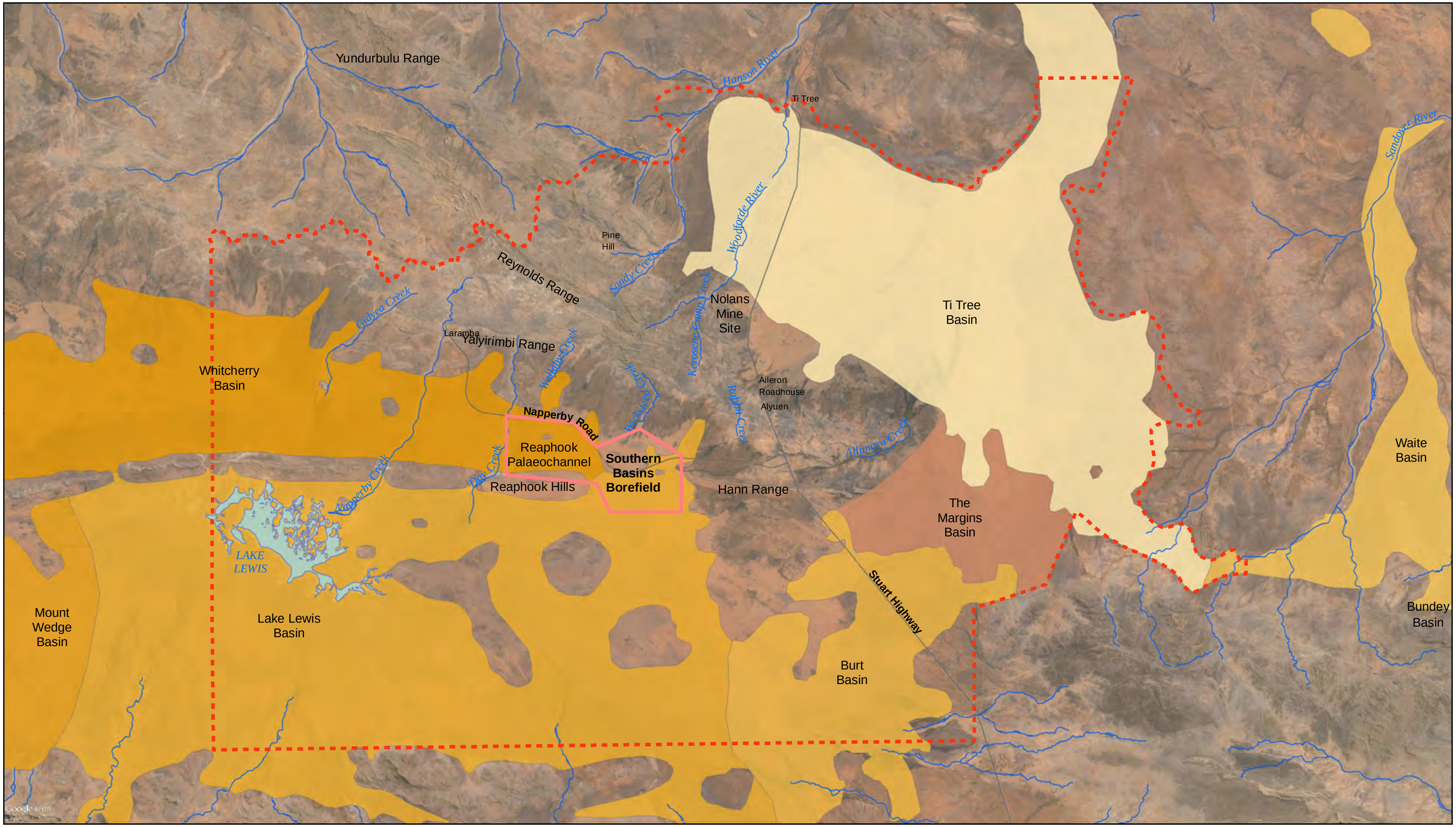
Precipitation averages approximately 320 mm/year but importantly for groundwater recharge, precipitation can fall as large rainfall events. Using the Territory Grape Farm weather station data (Appendix K), rainfall events were examined over a 28-year period. Twelve events were recorded for 60 mm or more per day, and 19 events were above 50 mm per day. Considering multiple day events (over five consecutive days), there are two occurrences exceeding 250 mm. Considering the low average rainfall, these events are significant as it is likely that most groundwater recharge and stream flow events result from rare, high-rainfall events rather than steady annual recharge. Ride (2014) documents a monthly rainfall of 100 mm or more being required to result in surface water flow in the Ti Tree Basin.

8.3.4 Basins

The basins (Southern Basins and Ti Tree Basin) in the study area are hydrogeologically similar (although not identical) to each other and to adjacent basins across central Australia. Unlike the Ti Tree Basin, which has been studied in detail and used extensively as a groundwater source, the Southern Basins in the study area have not previously been investigated in detail nor have they been used extensively as a groundwater source.

The Southern Basins encompass Cenozoic sedimentary basins previously referred to as the Whitcherry Basin, the Mount Wedge Basin, the Burt Basin and Lake Lewis Basin (Figure 8-2).

The Southern Basins are considered to be connected to the Ti Tree Basin in an area referred to as The Margins. Despite the connection, The Margins are primarily a subtle groundwater divide with water flowing north of the divide to the Ti Tree Basin and south of the divide to the Southern Basins. To the east, the Ti Tree Basin is connected to the Waite Basin (and then Bundey Basin) and to the north it is believed to be connected to the Hanson Palaeovalley (Figure 8-2).



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0 10 20 30 40

Kilometres

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

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LEGEND

- Roads
- Waterways
- Groundwater Study Area
- Southern Basins Borefield
- Lake Lewis
- Ti Tree Basin

Distant Basins and Palaeovalleys

- Bundey Basin
- Waite Basin

Southern Basins

- Burt Basin
- Lake Lewis Basin
- Mount Wedge Basin
- Whitcherry Basin
- The Margins

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Nolans Project
Environmental Impact Statement

Job Number	4322301
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Date	13 Apr 2016

Hydrogeological study area

Figure 8-1

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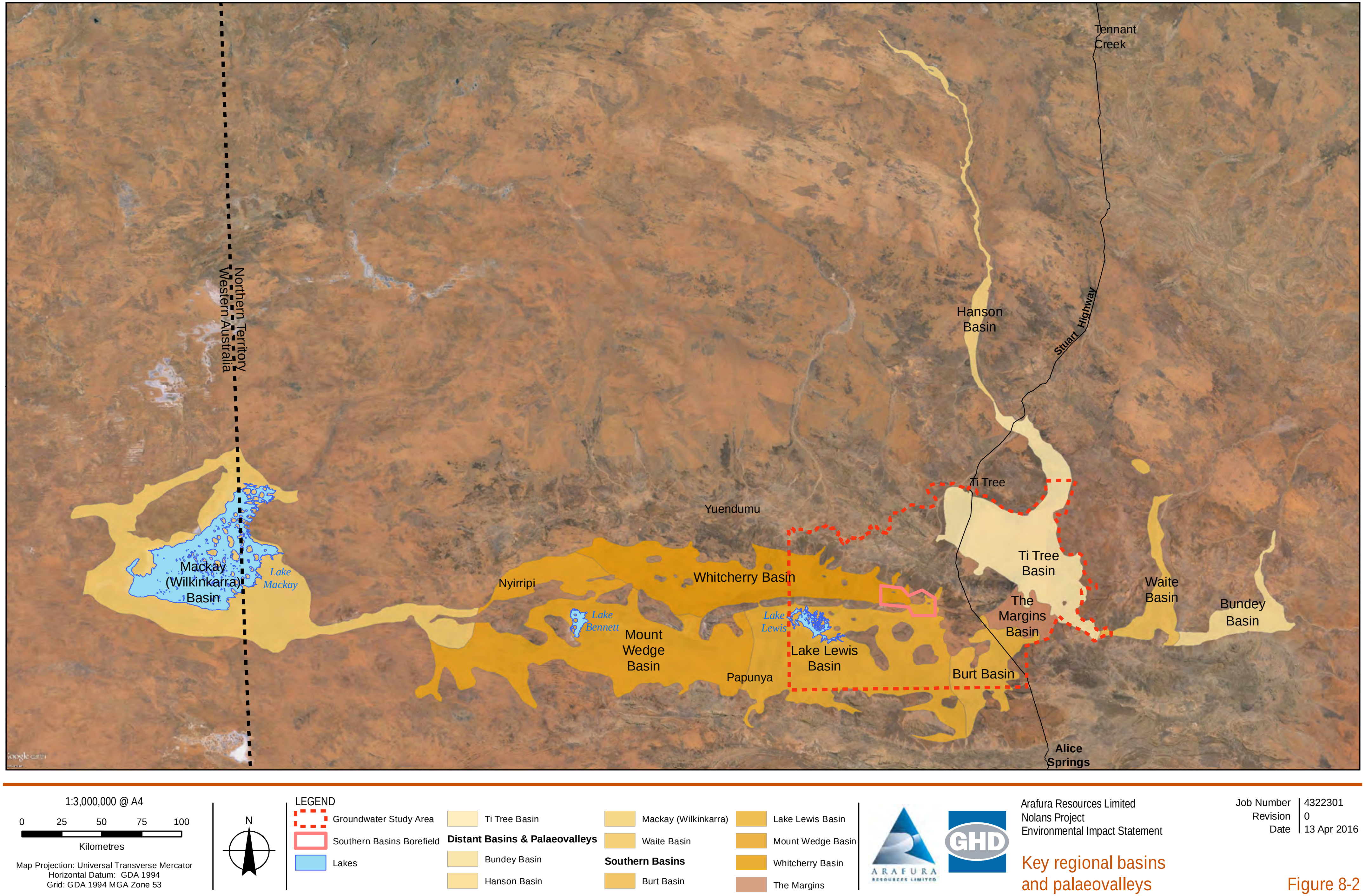
Level 5 66 Smith Street Darwin NT 0800 Australia T 61 8 8982 0100 F 61 8 8981 1075 E drwmail@ghd.com W www.ghd.com

Data source: Google Earth Pro - Imagery (Date extracted: 14/05/2015). GA - Roads, Waterways, Lake Lewis, Placenames (2015). GHD - Groundwater Study Area, Southern Basins Borefield (2015). Created by: CM



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Revision	0
Date	13 Apr 2016

Key regional basins and palaeovalleys

Figure 8-2

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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: 14/05/2015). GA - Roads, Lakes, Placenames, Palaeovalleys (2015). GHD - Groundwater Study Area, Southern Basins Borefield (2015). Created by: CM

8.3.5 Surface water features

Surface water features important to the study area are also presented in Figure 8-3. The important surface water drainage features within the study area flow only as a result of precipitation falling within the study area. Surface water flows originate in the catchments of the Reynolds Range and Yalyirimbi Range. These flows typically result in terminal creeks (i.e. their flow does not make it to a secondary water feature, i.e. a lake or river) including the named features Gidyea Creek, Day Creek, Wallaby Creek, Wicksteed Creek, Kerosene Camp Creek, Rabbit Creek and Allungra Creek. Napperby Creek is the exception in that it discharges to the endorheic basin, the ephemeral Lake Lewis, following periodic high rainfall events. Likewise, the Woodforde River also discharges to the Hanson River downstream (north) of the study area. No significant surface water drainage features originate from the Hann Range, Reaphook Hills or in the low-lying dune country of the relatively flat plains of the Ti Tree Basin and Southern Basins.

8.3.6 Water users

Groundwater from the basins is the primary source of drinking water in the study area. Power and Water Corporation provide groundwater to communities at Ti Tree, Pmara Jutunta, Laramba (Napperby); and the Central Desert Regional Council provides water to the Alyuen Community, Aileron Station Homestead and Aileron Roadhouse. Groundwater is also used for domestic purposes at the other stations' homesteads in the study area, notably Napperby Station Homestead and Pine Hill Station Homestead.

Pine Hill Station Homestead is adjacent to a large permanent/semi-permanent surface water hole visible on aerial imagery, and it is understood Napperby Station Homestead sources drinking water from a permanent/semi-permanent surface water source located in the adjacent hills.

In addition to this domestic use, groundwater is important for the following uses:

- Stock water - primarily for cattle, is extracted from groundwater within the basins and basement rocks across the study area; and
- Irrigation for agriculture - extracted from the Ti Tree Basin mainly for table grapes and mangoes at Ti Tree Farms.

Environmental users of water (not necessarily groundwater) in the study area include riparian vegetation, vegetation on the plains and in the hills, as well as fauna. With no permanent surface water across the study area, vegetation and fauna are either capable of surviving in between rainfall events or are able to tap into groundwater. Depths to groundwater levels are known to be shallow in isolated areas across the study area, but over the vast majority of the area are generally well below the reach of most vegetation (i.e. greater than 15 m). The following environmental users of groundwater have been identified:

- Riparian vegetation (dominated by *Eucalyptus camaldulensis*, colloquially referred to as river red gums) line the larger creeks and rivers in the study area. These larger creeks and rivers with riparian vegetation include, but may not be limited to, Napperby Creek, Day Creek and Woodforde River (Figure 8-1). It is conceivable that such riparian vegetation could tap groundwater (potentially even at depths greater than 15 m) and therefore these areas are potential groundwater dependant ecosystems, and are considered in this impact assessment.
- Water appears to be important for vegetation in floodout areas and at the toe of hills and ranges where runoff is highest. These areas are primarily dominated by *Acacia aneura* (mulga) woodland. These areas are considered in this impact assessment.

- Lake Lewis and surrounds is considered a site of conservation significance at a rating of National Significance. Due to this significance, Lake Lewis is considered in this impact assessment, despite the lake itself being a significant distance (30 km) from the borefield.
- Where water pools in basement rock-holes along drainage lines or in depressions in the outcropping rock mass, these provide a source of water for environmental use until evaporation depletes the water. Such features are present in the hills and ranges across the study area and these features are considered in this impact assessment, despite their distance from extraction points and their low permeability settings.

Water users are depicted in Figure 8-4.

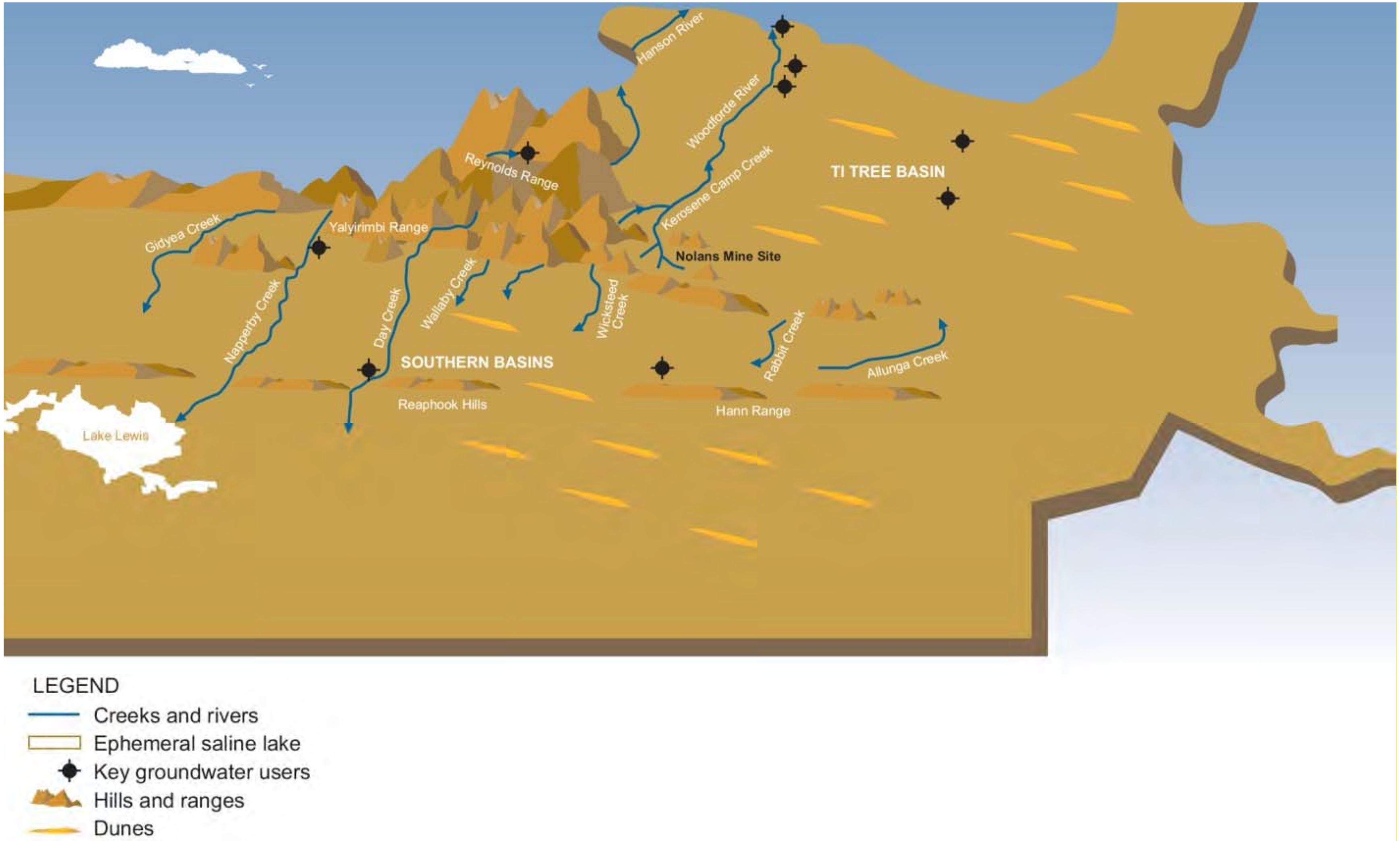

Figure 8-3 Study area surface water features

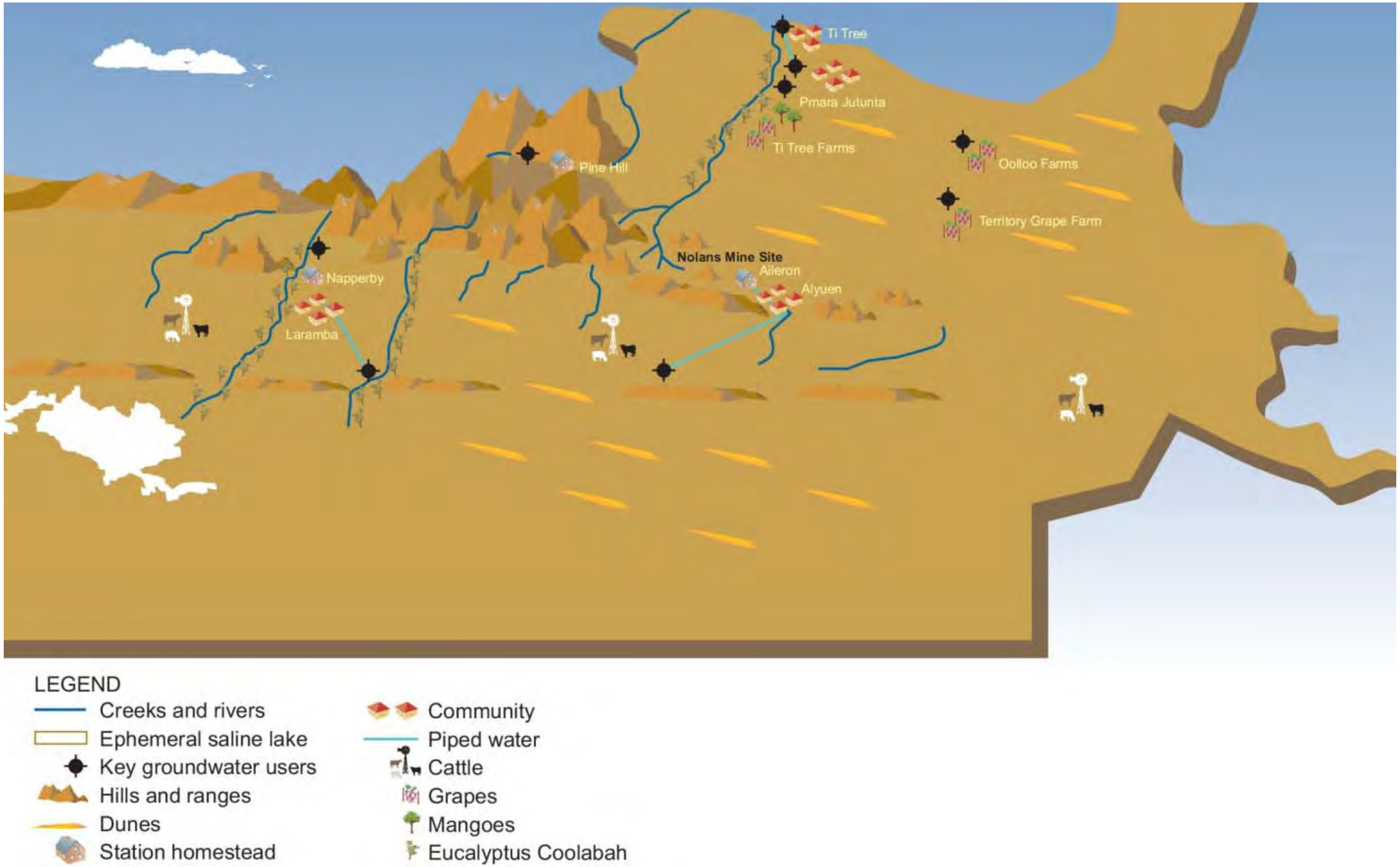

Figure 8-4 Study area water users

8.3.7 Conceptual water flows

Conceptual flows are represented in Figure 8-5 and are divided into the following groups:

- Boundary conditions
- Recharge
- Evapotranspiration and
- Groundwater extraction.

Boundary conditions

Upper no flow boundaries are the topographic high of the ranges and no flow boundaries of the basin boundaries. The divide between the Ti Tree Basin and the Southern Basins is a connected groundwater high, and thus no boundary condition is applied.

The Southern Basins have three key groundwater flow outputs (Figure 8-5):

- North of the Reaphook Hills westward through the deep aquifer
- South of the Reaphook Hills westward through the aquifer and
- Potentially through discharge at surface into Lake Lewis.

No surface water, significant to the hydrogeological assessment, flows into the study area but surface water leaves the system through the Hanson River and Woodforde River.

Recharge

Recharge throughout the Ti Tree Basin has been the subject of multiple studies and the groundwater assessment (Appendix K) makes use of the previous findings and estimates. Throughout this broader study area, classification of recharge (Figure 8-5) includes recharge through:

- Fractured rocks of the ranges and hills
- Alluvial fans and plains immediately adjacent to the ranges and hills where runoff infiltrates into the plains and
- Infiltration from Lake Lewis and areas locally referred to as ‘swamps’ and ‘clay pans’, following inundation events.

Evapotranspiration

The most evident illustration of evapotranspiration is the ephemeral, saline Lake Lewis where water clearly leaves the system as evaporation. Diffuse evapotranspiration occurs across the study area from vegetation, soil (as well as sediments and rock) and water bodies. Additionally, where water tables are shallow, trees (primarily mulga in the study area), shrubs and grasses (i.e. spinifex) are likely to tap groundwater and provide areas of higher evapotranspiration.

Groundwater extraction

Groundwater is extracted from the Ti Tree Basin for irrigation, stock and domestic purposes as discussed above in Section 8.3.6 and these locations are represented in Figure 8-4 at the key bores. Elsewhere in the study area, localised small-scale groundwater extraction occurs for stock and domestic purposes. An additional groundwater extraction of 4.5 GL/year for a 43-year period is proposed for the Nolans Project. The impact of this extraction is the focus of this study.

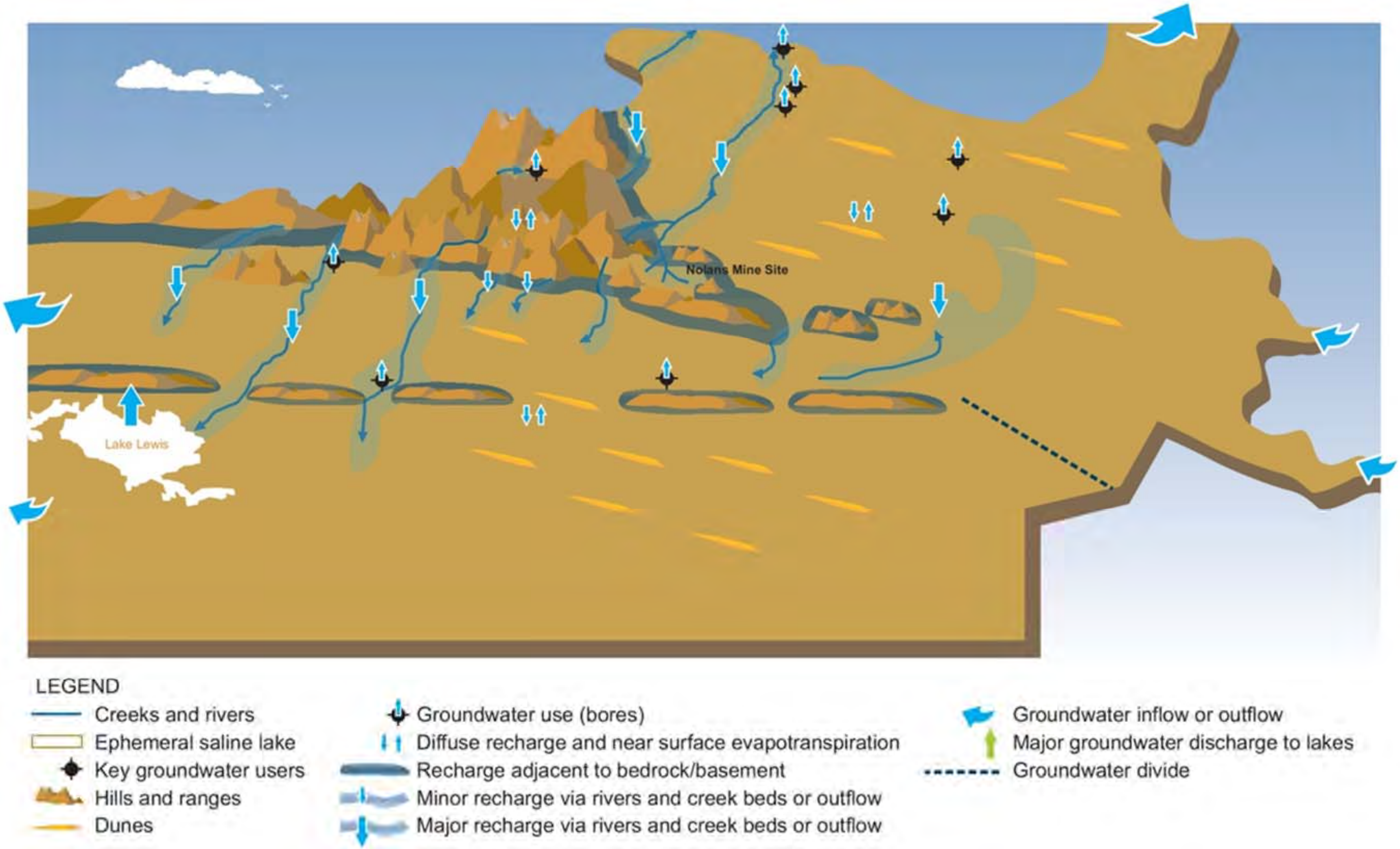

Figure 8-5 Study area conceptual water flows

8.3.8 Groundwater chemistry

A groundwater sampling and analyses dataset consisted of 158 samples from 71 bores (the dataset is summarised in Appendix K). The groundwater chemistry plotted by aquifer type displays a broad spread of water types, but there is a linear trend likely to be resulting from increases in chloride (Cl) content which may be associated with the evolution of groundwater, potentially driven by evaporation.

Groundwater quality (and chemistry) is variable in all units, however the general trend is that alluvial, shallow fluvial, and calcrete aquifers are 'fresher' than the Reaphook Palaeochannel aquifer and the upper Ti Tree Basin aquifer, which in turn are 'fresher' than basement aquifers. There are exceptions to this, but the general trend for the conceptual model is hypothesised to be that groundwater quality:

- Deteriorates with proximity to basement rocks (due to dissolution associated with weathering) and discharge locations (due to evaporation and subsequent concentration of constituents) and
- Improves marginally with proximity to preferential recharge locations (i.e. the Day Creek and Reaphook Range intersection) and where diffuse recharge is not associated with runoff from basement rocks (i.e. the centres of basins and The Margins area).

8.4 Groundwater modelling

A numerical groundwater model was built to represent the:

- Existing groundwater system (a steady-state numerical groundwater flow model)
- Groundwater system under the influence of the project's operating conditions (a predictive transient numerical groundwater flow model)
- Groundwater system under closure conditions (a long-term [1,000 year] predictive transient numerical groundwater flow model).

The model is calibrated to groundwater level information and not groundwater flow information. The model relies on boundary conditions and material hydraulic conductivity information based on assumptions and estimations from previous investigations and those made during the field program.

According to the Australian Groundwater Modelling Guidelines, models are suitable for the following key specific uses (refer to Appendix K for more information):

- Predicting long-term impacts of proposed developments in low-value aquifers
- Estimating impacts of low-risk developments
- Understanding groundwater flow processes under various hypothetical conditions
- Provide first-pass estimates of extraction volumes and rates required for mine dewatering
- Developing coarse relationships between groundwater extraction locations and rates and associated impacts.

The model is designed to test two primary stresses (sources of flow in or out of the model) that will be added to groundwater system as a result of the Nolans Project. These are:

- The mine (modelled as drain cells to represent and quantify sump pumping, i.e. flows are outputs from the model)
- The borefield (modelled as well cells to represent bore pumping, i.e. flows are inputs to the model).

Secondary stresses include stock bores, Ti Tree Basin bore pumping for horticultural irrigation, and community bores (Pmara Jutunta, Alyuen and Laramba). These bores are included in the transient model as constant-rate stresses, such that the impacts of the mine and borefield can be isolated from these pre-existing stresses.

Tertiary stresses include recharge and evapotranspiration. Like the bores, recharge and evapotranspiration are included in the transient model as constant-rate stresses, such that the impacts of the mine and borefield can be isolated.

The modelled solution represents a non-unique solution. A different combination of parameters could be applied resulting in an equally valid prediction which could result in impacts with differing magnitudes; however, the modelling does provide a valuable tool capable of quantifying the impacts based on reasonable documented inputs.

Obtaining a temporal dataset (ideally through the deployment of a fleet of water level loggers) and calibrating the transient model to a temporal dataset should be considered the next step in refining the groundwater model.

8.5 Assessment of potential impacts

This section examines the potential impacts the Nolans Project will have on groundwater quality, chemistry and drawdown.

8.5.1 Modelled flows

The groundwater flow regime is predicted to significantly change in the mine area and result in a permanent sink (i.e. perpetually discharging low point) due to evaporation exceeding pit water inflow.

The predicted mine dewatering peaks at 4,000 m^3/day (46 L/s or 1,450 ML/year) and steady-state post-closure inflows at approximately 700 m^3/day (8 L/s or 250 ML/year). The primary source of the water is from the basement rocks and only a minor proportion is from the Ti Tree Basin. In previous assessments, the basement water has not been considered a contribution to the Ti Tree Basin or Southern Basins, however, in reality it is likely to make some minor contribution.

Despite the 8 L/s of long-term modelled pit inflow, there was no significant change in the Ti Tree outflow. The modelled outflow only decreased by 0.03% representing a peak change of 4 m^3/day or 0.05 L/s at the end of the 1,000-year closure modelled period.

Flowthrough of the Ti Tree Basin is unlikely to be impacted at a measureable or observable amount. Flowthrough and availability for evapotranspiration within the Southern Basins is likely to be lower but not by an amount that a material impact is envisaged.

8.5.2 Modelled groundwater elevation and flow directions

The modelled groundwater flow regime displays almost no change (i.e. no impact) at the model (regional) scale when viewed from a flow direction or groundwater head perspective. At this scale, the impacts to flow direction and groundwater head are very localised to the mine area and adjacent to the Southern Basins borefield bores in the Reaphook Palaeochannel area while in operation.

No reversal of groundwater flow direction occurs anywhere within the model area during mining, except for immediately adjacent to the pit and immediately adjacent to the borefield bores (but not across aquifer, i.e. groundwater flow in the borefield aquifers is still westwards despite the pumping).

The modelled area of reversal at the end of the 1,000-year closure period extends within the basement rocks radially from the mine for approximately four kilometres towards the Aileron Station Homestead and Aileron Roadhouse area.

The modelled area of inflow towards the pit is limited to an area with the following average radii measured from the centre of the pit (which itself has an average radius of approximately 0.75 km):

- After 10 years of mining, approximately 1 km
- After 20 years of mining, approximately 1.5 km
- After 30 years of mining, approximately 2 km
- At the end of mining, approximately 2.5 km
- After 100 years of closure, approximately 4 km and
- After 1,000 years of closure, approximately 5 km and extending northwest along the basement rocks.

This demonstrates that the modelled extent of the inflow cone during mining is limited in extent to almost only the area actually disturbed by mining (i.e. much of this area is beneath the waste rock dumps and TSF.

8.5.3 Modelled drawdown at the mine site

The drawdown associated with mine site groundwater extraction is presented visually in Figure 8-6 to Figure 8-10. The modelled groundwater drawdown is very large at the pit site, but is likely to have very steep gradient due the low permeability of the rock mass surrounding the orebody.

Peak pit groundwater inflows of 4,000 m^3/day (46 L/s), equates to approximately 260 m of drawdown in the mine area at the completion of mining. Steady state post closure inflows to the pit of approximately 70 m^3/day (8 L/s), equates to approximately 80 m of drawdown during closure as the water rebounds to a level where groundwater flow equates to evaporation.

Riparian vegetation

Groundwater levels are predicted to be lower within the drawdown cone associated with the open pit, and the riparian vegetation immediately adjacent to the mine area will be directly, and irreversibly, impacted by this, both upstream and downstream in Kerosene Camp Creek.

The impact will likely be the result of groundwater drawdown as described above, but also the complete removal of periodic surface water flow, either directly via creek flow or indirectly during recharge to groundwater, due to the creek diversion works associated with mining operations.

The extent of the impact to riparian vegetation will be greatest immediately adjacent to the pit and decrease radially with distance from the pit. A reasonable estimate for the down gradient extent of this has been made, based on the both the modelled drawdown cone and the point where Kerosene Camp Creek receives additional surface water flow from adjacent catchments (which is likely to in part mask this impact) at the confluence with Nolans Creek. This length of Kerosene Camp Creek beyond the mining area, that is unlikely to capable of maintaining the current riparian vegetation, is less than one kilometre.

At this point the groundwater model predicts a drawdown of two metres during mining but approaches 20 m in the long-term closure model (1,000 years). This impact may, in part, be masked by recharge from continued surface water inflow beyond the confluence of Nolans Creek but this has not been explicitly incorporated into the modelling.

Stock water use

The small aquifer largely confined to the orebody at the mine pit will be almost completely removed during mining operations. Aileron Station water supplies near the pit will be impacted by the proposed mine dewatering and remain impacted beyond mine closure. At other existing bores in basement aquifers and adjacent materials, the drawdown impacts are likely to be minor in the long term but not materially affected by mine drawdown during their anticipated operational life.

At Pine Hill Station, groundwater for stock water in the Kerosene Well area eight kilometres downstream of the mining lease (bores RN010759 and RN012624) is beyond the cone of depression during mining. It is conceivable that these local resources may be impacted due to the pit void limiting flowthrough beyond mine closure; however, groundwater modelling predicts no impact at the Pine Hill Station Homestead and nearby outstation.

Groundwater availability for stock use within the Ti Tree Basin itself is highly unlikely to be measurably impacted. Despite the 8 L/s of long-term modelled pit inflow, there was no significant change in the Ti Tree outflow.

Irrigation for horticulture and viticulture

Groundwater availability for irrigation for horticulture and viticulture within the Ti Tree Basin is highly unlikely to be measurably impacted. The same measure for water availability for stock use has been applied to water availability for irrigation for horticulture within the Ti Tree Basin. The groundwater modelling indicates that, for example, the Ti Tree Farms area is beyond the cone of depression during mining, and beyond any measureable drawdown impact during the 1,000-year closure modelled period.

Drinking and domestic water

Like the above uses, drinking water supplies within the Ti Tree Basin including those at Pmara Jutunta, private farms and station homesteads are not likely to be impacted by drawdown associated with mine dewatering.

There are no drinking water users in the mine area and existing groundwater is not of a quality that drinking water could be a future beneficial use.

It is understood that drinking water for Aileron Station Homestead, Aileron Roadhouse and Alyuen Community is currently sourced from the Southern Basins.

At the location of existing basement bores in the Alyuen Community and the Aileron Station Homestead and Aileron Roadhouse area, that may have previously been used for drinking water, groundwater levels may be impacted in the long term by mine drawdown. It should be noted that these waters are not currently considered to be of a quality to have a beneficial use as drinking water.

8.5.4 Modelled drawdown at the borefield

The Southern Basins borefield is planned to be operated at approximately 13,000 m^3/day (150 L/s or 4,700 ML/year). Modelled drawdown in the water table from the operation of the Southern Basins borefield peaks at approximately six metres the centre of the borefield. The drawdown associated with borefield groundwater extraction is presented visually in Figure 8-6 to Figure 8-10.

The modelled groundwater drawdown is very large in terms of its extent. As such the flow rates should not be considered ‘sustainable’ in the long term (i.e. indefinitely) as it is unlikely to be replaced by recharge at the same rate as the proposed abstraction rate. However, despite it being unsustainable in the long term, the borefield is considered an appropriate use of the aquifer provided borefield abstraction ceases at the end of mining and processing operations and the aquifer be allowed to recover. The minor current and potential future uses should not be impacted in a material manner, although it is recognised that some drawdown at nearby stock and drinking water sources is likely to occur.

In the vicinity of the Laramba and Napperby groundwater supply area, modelled drawdown from the borefield peaks in the order of 1.3 m and rebounds rapidly once pumping ceases (Appendix K). This drawdown could result in minor incremental increases in pumping costs and minor decreases to yields in existing bores. Groundwater supply bores in such settings are commonly designed and operated with tens of metres of contingency for drawdown (to minimise impacts of drawdown from the operating bore itself) and this is the case at the Laramba groundwater supply area. The modelled drawdown therefore will be very unlikely to have any material impact on the volume of water available to supply Laramba and Napperby at either the actual bores or within the overall aquifer. Even if demand at Laramba and Napperby were to increase substantially, the modelled drawdown would be very unlikely to have any material impact on the water availability from the Laramba and Napperby groundwater supply area, and be very unlikely to be a limiting factor for water supply. In any event, given the setting, it is not the aquifer itself but the number of bores, current yields or size of pipelines (or other infrastructure) that are likely to be limiting factors for supply, to be able to meet potential significant increases in demand.

Riparian vegetation

Modelled drawdown from the borefield peaks in the order of 1.5 m in the vicinity of Day Creek (Appendix K) and rebounds rapidly once pumping ceases.

Water table level observations in an adjacent bore indicate water levels at up to 28 m below ground level. If riparian vegetation is currently dependent on the groundwater at this location, tree roots must be capable of extracting water from greater than 20 m deep, even accounting for the river bank and collar heights. If vegetation is capable of extending its root systems to such depths it is hypothesised that it is reasonable to expect that it could gradually extend its root system a further 1.5 m over the predicted 41-year drawdown period during mining.

There are no planned surface works in the Day Creek catchment that are likely to affect the recharge to either the surficial alluvials or the deeper aquifer material. If the vegetation is reliant on shallower or more temporary sources of water, there is no indication that there are any works proposed (including pumping of the borefield) that would alter these conditions.

Like Day Creek, there are no planned surface works in the Napperby Creek catchment that are likely to affect recharge to the area. However, unlike Day Creek, the modelled drawdown cone does not extend with significant magnitude to the Napperby Creek area during operations, but doubles in magnitude in the approximate 50 years following closure (Appendix K) as the aquifer recovers at the centre and extends laterally. The magnitude however is half that predicted at Day Creek and therefore it is reasonable to assert that even less impact (if any) is expected at Napperby Creek.

Floodout vegetation

In the Southern Basins, there may be minor localised impacts to floodout vegetation and/or soaks due to a decrease in groundwater availability for evapotranspiration. The impact will be determined by the current groundwater dependence and how the difference in availability of groundwater affects floodout vegetation and soaks. Given the scale of distance, the minor drawdowns predicted, the percentage differences in groundwater available and the gradual nature of the predicted changes, it is assumed that this impact will be low.

In the Reaphook Palaeochannel area of the Southern Basins the modelled difference in groundwater available for evapotranspiration peaks at approximately 100 years after closure. This is well after the pumps in the borefield in the modelled scenario have ceased but corresponds with the period the drawdown cone is still expanding laterally but decreasing in its vertical extent at the epicentre. The peak decreases in groundwater availability for evapotranspiration in the Reaphook Palaeochannel area is 12% or 306 m^3/day (3.5 L/s) and this rebounds to approach steady state at a decrease of approximately 1% or 31 m^3/day (0.36 L/s).

Lake Lewis and surrounds

The key indication for impact to Lake Lewis is whether the area is within the modelled drawdown cone but also if modelled net discharges to the area are affected.

The predicted drawdowns are negligible in the Lake Lewis area and not likely to be measureable. Despite this, the groundwater available for evapotranspiration, like in the Reaphook Palaeochannel area to the north, is likely to be impacted in the Lake Lewis area. The peak decreases in groundwater availability for evapotranspiration in the Lake Lewis area of the Southern Basins is 3% or 712 m^3/day (8 L/s) and this rebounds to approach steady state with a decrease of approximately 0.5 % or 103 m^3/day (1 L/s).

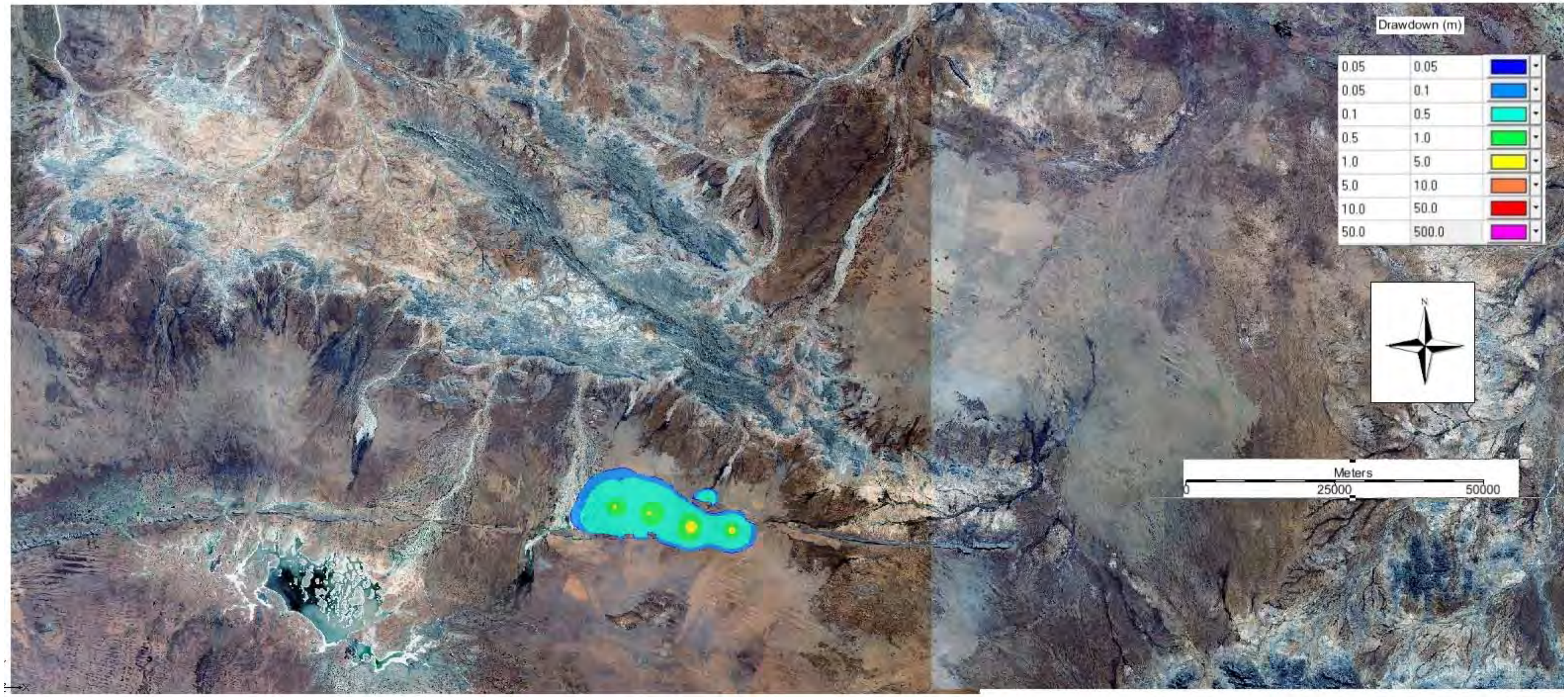

Figure 8-6 Modelled drawdown at commencement of mining 1/1/2020

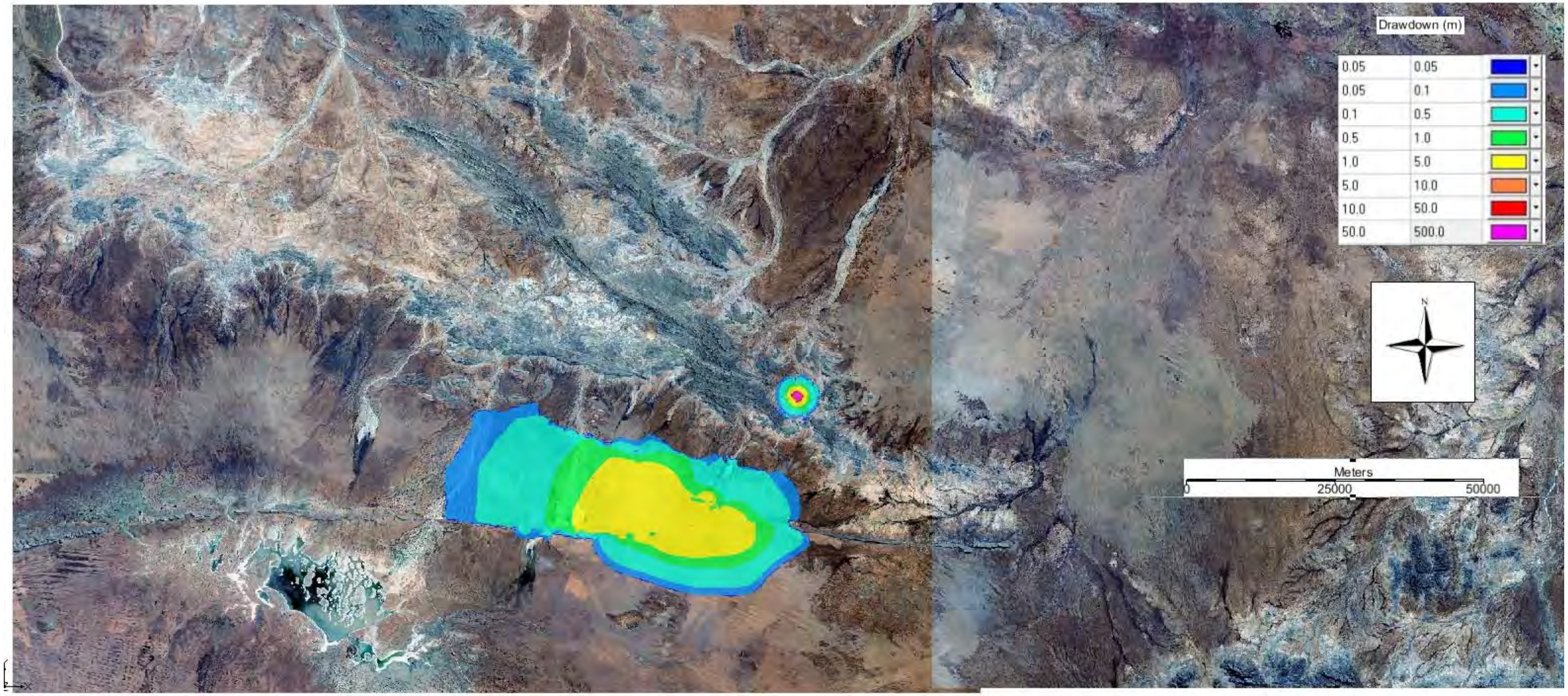

Figure 8-7 Modelled drawdown at approximately mid-way through mining 1/1/2040, 20 years after commencement of mining

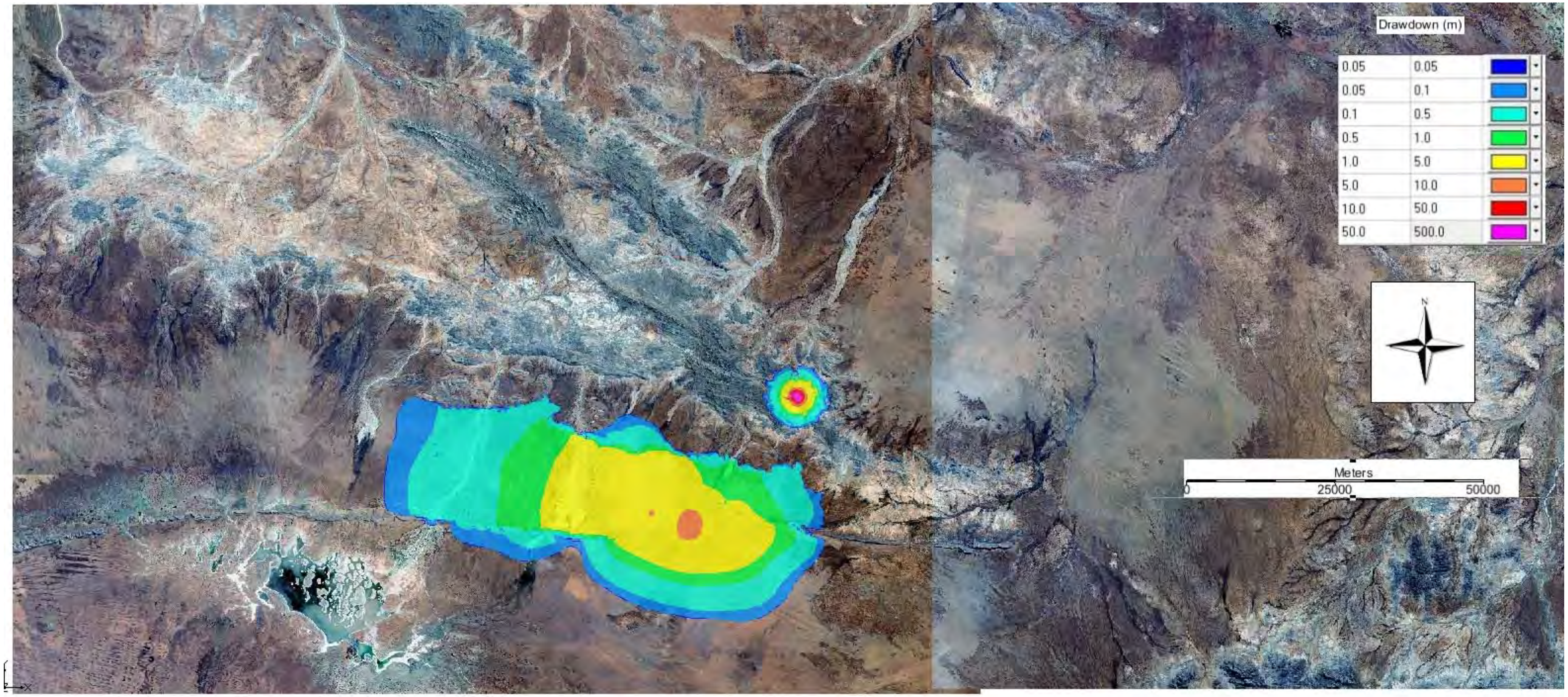

Figure 8-8 Modelled drawdown at end of mining 1/1/2060

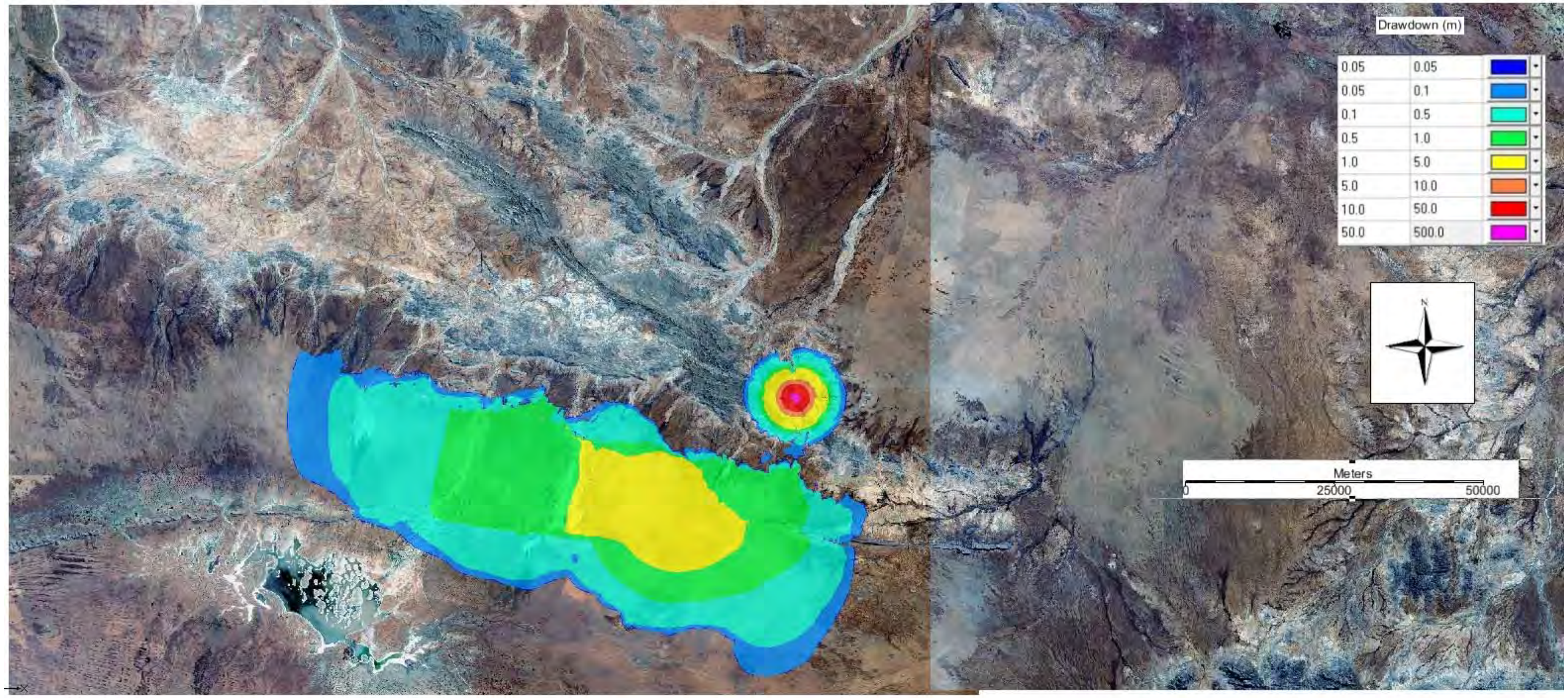

Figure 8-9 Modelled drawdown at 100 years of closure 1/1/2160

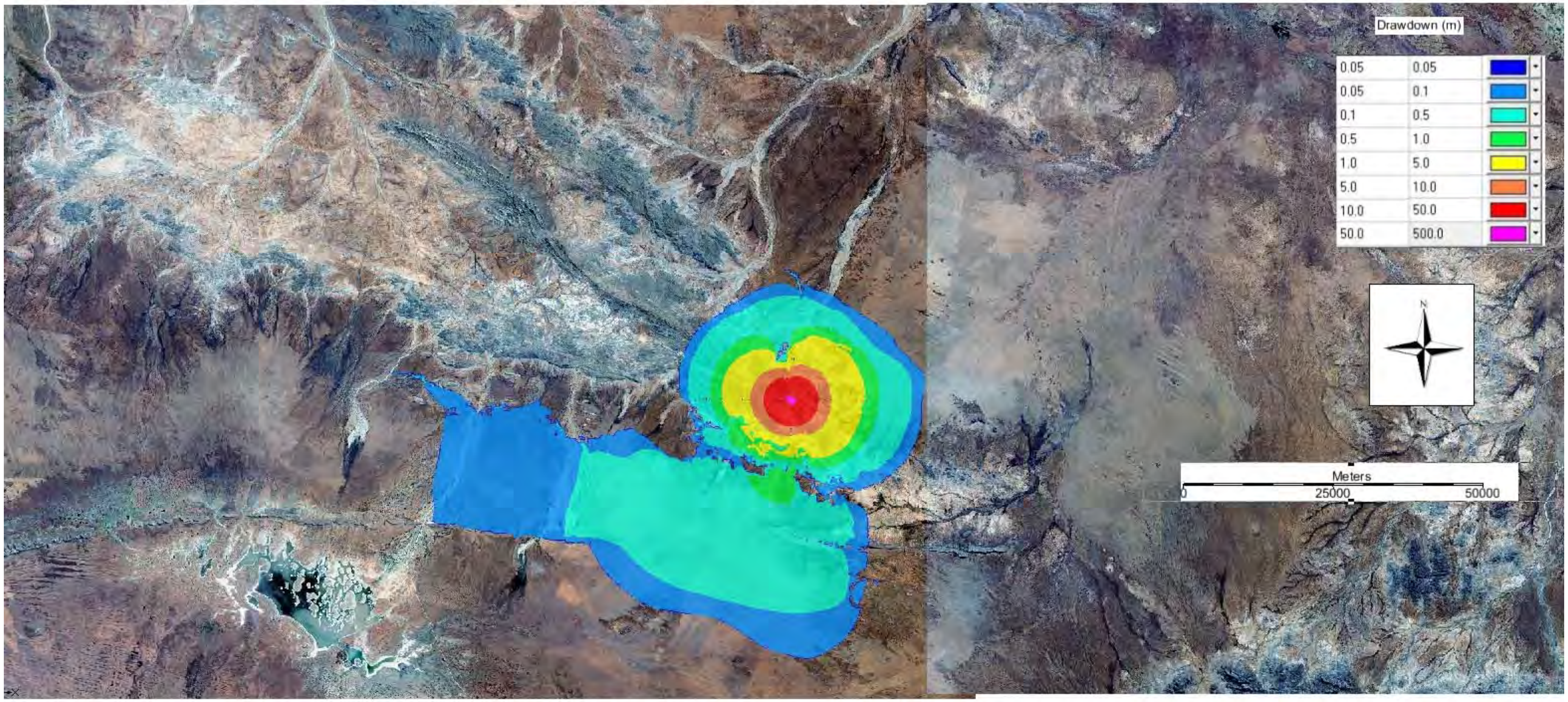

Figure 8-10 Modelled drawdown at 1,000 years of closure 1/1/3060

8.5.5 Groundwater chemistry and quality

The modelled groundwater flow regime displays almost no change (i.e. no impact) at the model (regional) scale when viewed from a flow direction or groundwater head perspective. As such, there is no justification for any speculation of material changes in groundwater chemistry or quality within the aquifer.

Despite this, conceptually there still remains the minor potential for hypothesised impacts based on the following:

- Extraction of groundwater from the Southern Basins could result in more groundwater with lower quality flowing from storage within the basement rocks
- Extraction of groundwater from the Southern Basins could draw fresher water associated with recharge from Day Creek eastwards altering the quality of drinking water available for extraction.

The aquifer under the influence of the proposed Southern Basins borefield pumping regime is likely to be under significantly more dynamic conditions than at present and under such conditions, a more uniform groundwater chemistry may develop.

Mine area

The chemistry of groundwater flowing towards the mining pit is unlikely to be materially different from the existing groundwater chemistry in the area. Once mining ceases, groundwater near the pit will begin the process of rebounding. A pit lake will form and the pit will slowly, partially fill until the water level reaches equilibration where the net evaporation is equal to natural groundwater inflow. This will then result in a process where water quality will slowly deteriorate and over time results in a hypersaline pit lake. Flow will be radially towards the pit lake and thus contribute to the concept of a zero discharge site. The likely chemistry of this pit lake has not been modelled; however, it is highly likely to be of no beneficial use.

In the highly unlikely event that the pit is filled and decants either to the surface water bodies or groundwater system (i.e. the pit lake rises above adjacent groundwater levels to the point where it is no longer behaving as a sink), this contaminated water could discharge. The mine closure design should ensure that all surface water runoff is diverted around and away from the pit so that the pit remains a groundwater sink.

Acid and metalliferous drainage

Characterisation of Nolans waste rock and ore was undertaken for AMD predictions using chemical analysis, XRF and static and kinetic AMD testing. Further details are presented in Appendix L.

A total 154 static AMD tests comprising static net acid generation/net acid producing potential (NAG/NAPP) tests were carried out. Of the 154 samples, 25 samples represented pegmatite, 34 mineralisation, 25 gneiss and 70 schist. Only one sample out of 154 subjected to NAG/NAPP testing was identified as potentially acid forming (PAF). The tests indicated a very low risk of acid generation either during short-term storage of ore, or long-term storage of waste rock. A conservative threshold of 0.15% sulfur was recommended for confirmation NAG testing during operation.

Leachate salinity was low and fluoride was only slightly elevated in one sample but at a concentration consistent with ambient groundwater, hence the risk of generating saline or fluoride-rich leachate is low.

Seepage from ore or waste rock could contain elevated concentrations of some metals (particularly Zn, Al and Cr) and leached samples consistently exceeded ANZECC & ARMCANZ

(2000) Freshwater Aquatic Ecosystems 95% threshold and ambient groundwater concentrations. However, all leachate samples were within ranges acceptable for stock watering, where guidelines are provided in ANZECC & ARMCANZ (2000), including those for uranium and gross alpha and beta radiation, based on the total thorium and uranium content.

It is unlikely that leachate from the waste rock dumps will impact on existing poor quality groundwater or ephemeral surface water quality, when typical dilution factors are considered. Based on the overall chemistry of the waste rock and ore, the risk of acid, metalliferous or saline drainage is low and the material can generally be managed as non-acid-forming.

The AMD Management Plan (Appendix L) provides for separate storage of all potentially acid-forming material, or blending of any potentially acid-forming material with non-acid-forming and acid-consuming material. This management process will ensure that any residual AMD impacts can be minimised.

The AMD assessment shows that with appropriate design and operational control measures (refer section 8.6) the residual AMD risk on site is very low. This residual risk will be monitored to confirm that waste rock dump design and operational controls and management measures are effective.

Processing site, tailings and residue storage facilities

As all storage facilities are designed as zero discharge facilities (i.e. evaporation controlled), they will be designed or managed such that they do not breach or decant either to the surface water bodies or seep into groundwater systems.

A breach or seepage of contaminated water from the processing site is likely to be in direct contact with the Southern Basins aquifer either via the shallow Quaternary material or along the interface between the Quaternary or Cainozoic material and the underlying basement material. Particle travel distances have been calculated based on assumed effective porosity values and key outputs from the model. These calculated particle travel distances are in the order of 100 m in a year or 10 to 20 km over the 1,000-year closure period. If the flow was to be through basement material alone, then particle travel distance is only in the order of hundreds of metres over the 1,000-year closure period. Monitoring bores near the processing site will allow detection of potential contamination and allow mitigation measures to be implemented to limit these potential impacts.

A breach or decant at the TSF would represent a similar outcome, however, depending on the scale, duration and timing, could be self-managed by the down-gradient pit acting as a groundwater sink. Like the processing site, a potential mechanism would be flow in the unsaturated Quaternary material or along the interface with the underlying basement material (i.e. along the Nolans Creek drainage line). These calculated particle travel distances are in the order of 50 m in a year, and as such flow would, within years, leave the site towards the north. In contrast, particle travel distances if flow was only within the basement material were calculated at less than 100 metres of flow outwards over the entire mining and early closure period before turning inward towards and ultimately being captured by the pit. As with the processing site, monitoring bores will be located near the TSF to allow detection of such an event and enable appropriate mitigation / management measures to be implemented.

These facilities will be designed to an appropriate standard and managed. They will be monitored during operation and through closure in order to maintain the long-term security of the tailings, residues and associated liquors.

8.6 Mitigation and monitoring of impacts

Monitoring the impact as well as monitoring to validate the predicted impacts will be required. Mine facilities will have a network of groundwater monitoring bores installed. The bores will be monitored for water levels, water chemistry and water quality as per the Water Management Plan (Appendix X).

In addition, the borefield will be monitored for water levels, water chemistry and water quality. As a minimum existing bores will be included for monitoring of the aquifer during and after the pumping period and for the monitoring of key specific potential impacts as outlined in Table 8-1.

Table 8-1 Proposed Southern Basins borefield monitoring

Location	Aquifer	Monitoring for potential Impact
West of Day Creek	Reaphook Palaeochannel	Day Creek
East of Day Creek	Reaphook Palaeochannel	Day Creek and Laramba/Napperby drinking water supply
Gap between Hann Range and Reaphook Hills	Reaphook Palaeochannel	Drawdown towards the south
South of gap between Hann Range and Reaphook Hills	Reaphook Palaeochannel	Southern extent of drawdown
Centre of Southern Basins borefield	Reaphook Palaeochannel	Epicentre of borefield drawdown
Centre of Southern Basins borefield	Reaphook Palaeochannel	Epicentre of borefield drawdown
Immediately north east of Southern Basins borefield	Reaphook Palaeochannel	Drawdown immediately towards the north east
Immediately east of Southern Basins Borefield	Reaphook Palaeochannel	Drawdown immediately towards the east
North eastern extent of Southern Basins	Alluvials	Drawdown towards the east
North of Southern Basins borefield	Reaphook Palaeochannel	Drawdown towards the north
North of Southern Basins borefield	Basement	Drawdown towards the north
North eastern extent of Southern Basins	Basement	North eastern extent of drawn

Implementation of the following management plans (Appendix X) would occur prior to construction commencing and would include groundwater management and protection:

- Mine Management Plan
- Sediment and Erosion Control Plan
- Water Management Plan including a groundwater monitoring program.

Measures to prevent potential spills from impacting groundwater will include:

- Development and implementation of a hazardous substances management plan

- Provision of self bunded storage for 110 per cent of the largest storage volume, in accordance with Australian Standards
- No underground piping would be included in the proposal design.

The mine pit will include the following features to minimise contamination of water resources:

- Potentially acid forming (PAF) material encapsulation cells within ex-pit waste rock dumps, if PAF is encountered
- Dumps and fill areas profiled to shed and capture runoff
- Clean, dirty and contaminated water drainage systems
- Surface water management basins
- Selective materials handling and placement using mine schedule and geochemical model
- Controlled and managed site drainage and release
- Compaction of construction material and waste rock.

To monitor for potential breaches of the slurry pipeline from the processing plant, the plant would include:

- Notification of disruption to flow to minimise impacts from spill
- Flow meters
- Pressure sensors
- Shift based visual inspections
- Design - spray deflectors on welded joints and
- Periodic visual inspections of pipeline corridors, to occur twice per shift.

To prevent seepage of tailings and residue water containing metals at levels potentially exceeding guideline thresholds the following measures will be considered:

- Selection of appropriate risk category and adherence to relevant design standards for the provision of adequate storage capacity and freeboard allowance
- Provision of a seepage interception and collection system
- Embankment piezometers and survey pins, regular dam inspections
- Adherence to prescribed maximum operating level and retention of freeboard
- Monitoring program for phreatic levels within embankments
- Testing to confirm chemical properties
- Thickener on concentrator to reduce volume of entrained water entering the tailings storage facility
- Supernatant reclaim
- Ongoing AMD sampling and analysis
- Multi-stage neutralisation process (pH control).

Throughout mining, the following hydrogeological studies will be undertaken:

- Ongoing hydrogeological monitoring and analysis ad
- Validation, re-calibration and additional predictive groundwater flow modelling.

Sampling and analysis will be undertaken as detailed in the site procedure in the AMD Management Plan. The results will be used to validate AMD risk and management strategies in subsequent revisions of the document.

Additional testing and monitoring will be undertaken in the pre-production phase. This will include:

- Identification of suitable capping/encapsulation material and testing for dispersion, exchangeable cation, and general capping geotechnical parameters
- Additional laboratory testing
- Column and or barrel leach tests to commence to provide long-term leachate generation information and
- Additional metals to be added to laboratory and field analyses, if required, to cover the range of potentially elevated or mobile metals.

09

Biodiversity

9. Biodiversity

9.1 Introduction

This chapter describes the flora, vegetation and fauna present in the study area, including a description of biodiversity values at the species and ecosystem level, and in a local and regional context. This chapter also describes the potential direct and indirect impacts of the project on local and regional biodiversity, including TPWC listed threatened flora and fauna species. Mitigation measures that will be implemented in order to minimise the impact of project construction and operation area documented.

Section 5.4.1 of the Terms of Reference (TOR) for the preparation of an environmental impact assessment issued by the NT EPA for the Project provided the following environmental objective in relation to biodiversity:

> *The Project will maintain the conservation status, diversity, geographic distribution and productivity of flora and fauna, at the species and ecosystem levels, through the avoidance or management of adverse impacts.*

This chapter addresses the biodiversity values, as required in the TOR for the project.

The delegate of the Commonwealth Minister has determined that the project is a controlled action that has the potential to significantly impact listed threatened species and communities (under Sections 18 and 18A of *the Environment Protection and Biodiversity Conservation Act 1999* – EPBC Act). The project will be assessed under the Bilateral Agreement between the NT and Commonwealth governments.

Matters of National Environmental Significance (MNES) and other matters protected under the EPBC Act are discussed separately in Chapter 10. This chapter provides the environmental context and the detailed habitat information that is the background to a discussion of the impact on MNES.

Detailed flora and fauna assessments are provided in Appendix M and Appendix N respectively.

The total study area for flora and vegetation assessment is approximately 5, 692 ha (Figure 9-1). The study area for fauna, assessed on foot, vehicle and helicopter covered more than 110,000 ha (Figure 9-2) and included:

- approximately 65,000 ha in the Reynolds Range and Hann Range (both ranges are far larger than the area assessed) where targeted threatened species surveys (Chapter 10) were carried out for Black-footed Rock-wallaby, and
- 41,568 ha of the broader borefield area.

1:225,000 @ A4

0 2 4 6 8

Kilometres

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

N

LEGEND

- Water Bores
- Existing Roads
- Existing Access Track
- Waterways
- Study Area
- Borefield Area

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Arafura Resources Limited
Nolans Project
Environmental Impact Statement

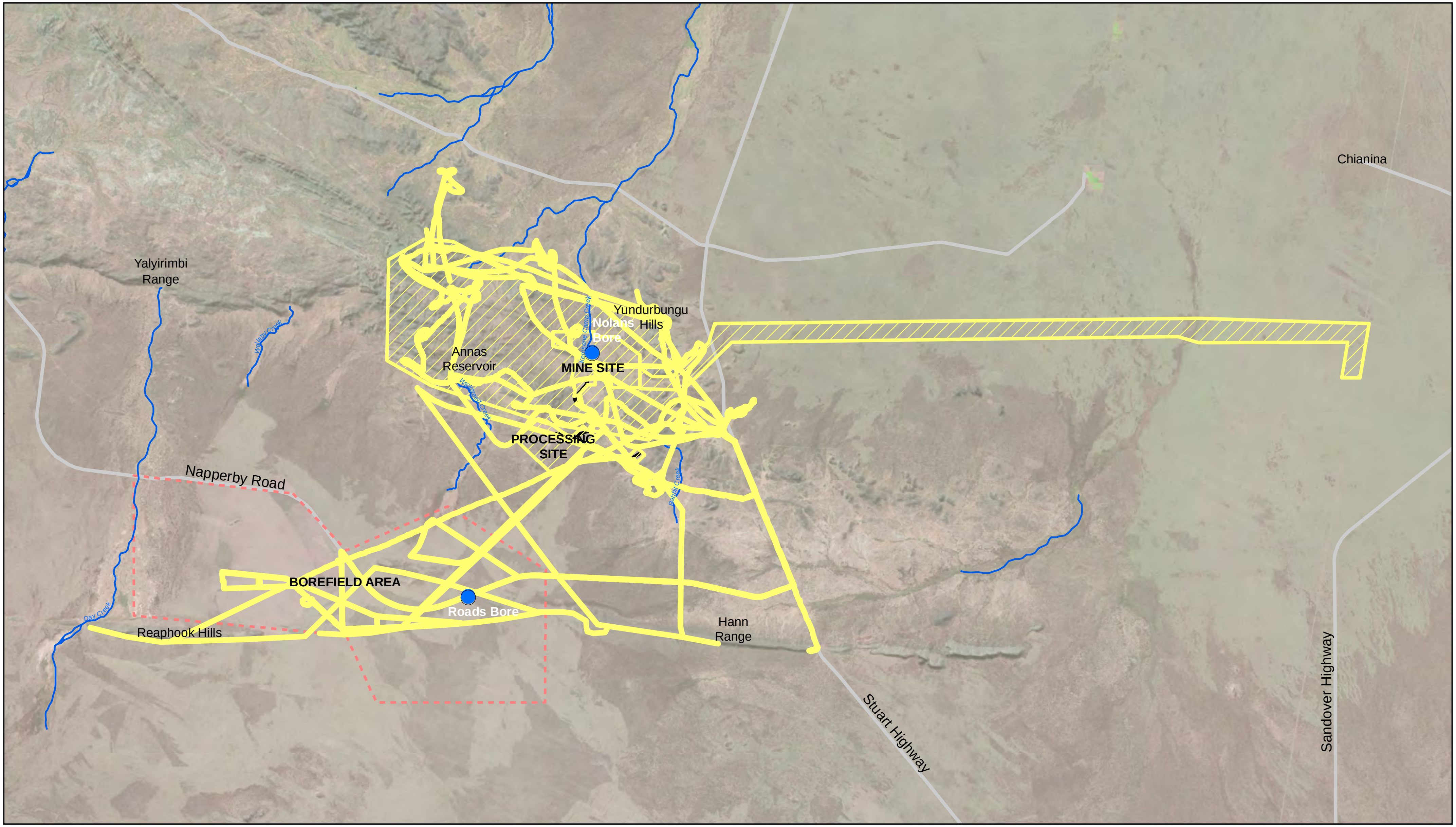
Job Number	4322301
Revision	0
Date	18 Mar 2016

Study area (flora and vegetation) Figure 9-1

G:\43\22301\GIS\Maps\4322301_025_StudyArea.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: GA - Imagery (2008), Roads, Waterways, Placenames (2015). ESRI - Shaded Relief (2009). ARL - Water Bores, Proposed Pipelines, Borefield Area, Proposed Mine Site, Treatment Plant and Accommodation Village (2015). Created by: CW, CM



1:425,000 @ A4

0 2.5 5 7.5 10

Kilometres

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

N

LEGEND

Water Bores
Existing Roads
Existing Access Track
Waterways
Study Area
Borefield Area

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Environmental Impact Statement

Job Number	4322301
Revision	0
Date	18 Mar 2016

Study area (fauna)

Figure 9-2

G:\43\22301\GIS\Maps\4322301_026_StudyArea.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: GA - Imagery (2008), Roads, Waterways, Placenames (2015). ESRI - Shaded Relief (2009). ARL - Water Bores, Proposed Pipelines, Borefield Area, Proposed Mine Site, Treatment Plant and Accommodation Village (2015). Created by: CW, CM

9.2 Bioregional context

The study area is located within the Burt Plain Bioregion, on the Aileron and Napperby pastoral stations which have been used for grazing since the early 1880s.

The bioregion covers an area of 73,605 km^2, which represents approximately 5% of the Northern Territory (NRETAS 2005). It is characterised by arid to semi-arid plains and low rocky ranges with some of Australia's best established and most extensive mulga (*Acacia aneura*) and other acacia woodlands (NRETAS 2005). Geologically the bioregion lies over the Arunta Province, Tennant Inlier, and small areas of Georgina, Wiso and Ngalia basins, with metamorphic, plutonic, and sedimentary rocks of Precambrian age.

One of the distinguishing features of the Burt Plain Bioregion is the predominance of earthy, alluvial soils as opposed to sandplains and sand dunes. It also has a relatively high density of mountain ranges, in the east, north and west of the bioregion.

In the Reynolds Range, northwest of the Nolans site (Figure 1-6), Mt Thomas reaches 1113 m. Running parallel and to the north of the Reynolds Range are the Anmatjira and Yundurbulu Ranges, both with peaks over 1000 m above sea level (asl) and with significant long-term freshwater springs. These ranges generate the major north flowing rivers of the study area.

Running south from the Reynolds Range are Napperby Creek and also Gidyea and Day creeks, which carry water about 50 km to the ephemeral Lake Lewis and the surrounding swamps. The mean annual rainfall data shows a regional area of relatively high rainfall in the area of the Reynolds, Anmatjira and Yundurbulu Ranges, however there are no permanent natural waters in the creeks running north and south, despite the mountains.

There are five broad vegetation types that have been mapped within the bioregion (Wilson *et al.* 1990), the most abundant being Acacia woodland. Other broad vegetation types recorded within the bioregion include Eucalyptus low woodland with tussock grass understory, Eucalyptus woodland with hummock grass understory, Hummock grassland and Tussock grassland (NRETAS 2005).

The Burt Plain Bioregion is known to contain more than 1100 flora species and 350 fauna species. However, the bioregion is one of the most poorly documented bioregions in the Northern Territory in terms of its biodiversity values (Neave *et al.* 2006), and it is consequently recognised as a national priority bioregion for conservation planning. Less than 0.3% of the bioregion is reserved in National Parks and other conservation reserves (NRETAS 2005).

There are 16 sites of botanical significance within the Burt Plain Bioregion, none of which occur within or near the study area (Neave *et al.* 2006). There are six sites in the bioregion that are listed in the directory of important wetlands. None of these are within or near the Nolans site.

There are no sites of conservation significance in or near the study area. Lake Lewis site of conservation significance is 30 km to the west.

Potential and existing threats to biodiversity that have been identified within the bioregion include exotic flora, introduced animals, fire, erosion, land clearing, grazing and mining (Neave *et al.* 2006). Much of the bioregion has been impacted by a range of broadscale processes such as grazing by livestock and/or feral animals, feral predators and weed infestations.

Exotic species are widespread and there are fifteen declared weed species currently listed under the *Northern Territory Weeds Management Act 2001* known to occur in the Burt Plain Bioregion. Other exotic plants species, most notably buffel and couch grass, also pose significant threats to some habitats.

9.2.1 Fauna and Habitat Characteristics (Neave *et al* 2006)

The fauna and flora habitat of the Burt Plain Bioregion are characterised by the following:

- Vegetation is predominantly mulga and other acacia woodlands with short grasses and forbs, and spinifex grasslands.
- Of the 1100 flora species, three are listed as vulnerable under the *Territory Parks and Wildlife Conservation Act* (TPWC Act) and one is listed as vulnerable under the EPBC Act. Additionally, 64 species are listed as data deficient, 41 listed as near threatened in the Northern Territory, and seven listed as endemic to the bioregion have been recorded.
- Much of the Burt Plain Bioregion was burnt in the summer months in 2001 and 2002. This wildfire period followed very wet years in 2000 and 2001. Fire appears to have been insignificant at other times i.e. between 1997 and 2005. Major fires in this period occurred between April and November and were probably less intense. As with other central Australian bioregions, the overall condition of the Burt Plain Bioregion is masked by a very strong rainfall effect, with degradation sometimes difficult to detect following a series of good seasons. Much of the bioregion has been impacted by grazing livestock and/or feral animals, feral predators and weed infestations. There are 19,500 records for 359 vertebrate species for the Burt Plain Bioregion. The majority of these are:
  - Birds (16,341 records and 183 species; 51.0% of all species)
  - Mammals (1,643 records and 63 species; 17.5% of species)
  - Reptiles (1,436 records and 104 species; 29.0% of species)
  - Frogs (80 records and 9 species; 2.5% of species).
- Although this species list appears comprehensive, the animals of the Burt Plain Bioregion are relatively poorly known and documented. Furthermore, an understanding of the habitat requirements of many species and species assemblages is limited.
- From a national and Northern Territory perspective, no extant vertebrate species are considered endemic to the bioregion.
- The Burt Plain Bioregion has suffered a substantial reduction in its mammal fauna over the last century. There are ongoing declines of some bird and mammal populations. Introduced predators are widespread. At least 15 of the 54 indigenous mammal species recorded from the bioregion are extinct or no longer occur in the bioregion. Several others have suffered population declines. Between two atlas projects conducted by Birds Australia (in the late 1970s and early 1980s, and again in the late 1990s and early 2000s), the Hooded Robin was found to have suffered a substantial decline. Several other birds are suspected to have undergone significant declines in the bioregion since European colonisation.

9.2.2 Previous disturbance and site history

The local area around the Nolans site has been used as grazing land for many years. There is evidence of clearing and disturbance associated with livestock primarily in the vicinity of Nolans Bore. This bore, including cattle yards, was for a long time the only stock watering point in a 15 km^2 area. As a consequence, vegetation in and around the bore has suffered significant long term degradation.

Vegetation clearing within and surrounding the Nolans site also has been associated with construction of a gas pipeline, the development of the Stuart Highway and a range of other roads and tracks.

An abrupt tree-line surrounding the paddock north-east of Nolans Bore suggests that that area (approximately 20 ha) has been cleared for grazing. Mineral exploration activity has also contributed to localised losses of native vegetation, in association with drilling, vehicle access etc.

9.3 Methodology

9.3.1 Desktop review

The following databases and literature sources were reviewed prior to conducting the field investigations:

- The Northern Territory Herbarium (Holtze) Database – to identify flora species previously recorded within a 20 km radius of the study area (DLRM 2015)
- The Department of Land Resource Management (DLRM) Fauna Atlas database was used to identify actual records of all fauna species known to occur within 10 km of the study area
- Commonwealth Department of the Environment (DotE) Protected Matters Search Tool (PMST) – to identify Matters of National Environmental Significance (MNES) listed under the EPBC Act potentially occurring in the locality (20 km radius) in February 2015
- Northern Territory land systems/vegetation mapping of the Southern Alice Springs District (NRETAS 2000)
- Aerial imagery – for preliminary vegetation map and to help stratify the placement of flora quadrats for the field survey
- Bureau of Meteorology online data (BOM 2015)
- Mapping of Sites of Conservation Significance in the Northern Territory (DLRM 2015)
- A fauna species list for the Burt Plain Bioregion
- Past survey reports to identify additional flora and fauna species records in or near the study area since 2006 and
- Other literature relevant to the study as part of the desktop assessment.

A number of ecological assessments for the Nolans Project have been completed over the period 2006 to 2015. These are summarised in Table 9-1. Baseline flora and fauna surveys were most recently undertaken from 27 April to 3 May 2015, and the methodology is detailed in the sections below.

Table 9-1 Summary of flora and fauna assessment at the Nolans Site 2006 to 2015

Date	Reference	Description
4 – 7 May 2006	Low Ecological Services	Flora and fauna survey of mine site.
21 – 24 November 2006	Low Ecological Services	Flora and fauna survey of mine site.
16-25 August 2010	GHD	Flora survey of the mine site and transport corridor (transport corridor no longer proposed).
30 August – 8 September 2010	GHD	Baseline fauna survey of mine site and a proposed haul route (note: haul route no longer included in proposed project footprint).

Date	Reference	Description
6 to 8 December 2011	GHD	Flora survey of the transport corridor (transport corridor no longer proposed), power station and accommodation village.
8 – 9 December 2011	GHD	Targeted Black-footed Rock-wallaby (MacDonnell Ranges race) survey of mine site only.
27 April – 3 May 2015	GHD	Flora and Baseline fauna survey of current project area incl. mine site, processing site, accommodation facility, access roads, utilities corridor (potable water pipeline, process water supply pipeline, power line corridor) and borefield area.
23 – 26 July 2015	GHD	Targeted surveys for Black-footed Rock-wallaby in the eastern end of the Reynolds Range, Hann Range, Reaphook Hills and outcrops in between.
21 – 23 July 2015.	GHD	The borefield area targeted surveys were undertaken to detect presence of any threatened species including the Great Desert Skink, Brush-tailed Mulgara and Greater Bilby.

9.3.2 Flora and vegetation assessment

Flora survey included local vegetation community mapping and botanical inventories; and an assessment of the condition of flora and vegetation communities within the study area.

A random-stratified approach was used to survey a representative range of floristic communities and habitats across the study area. Sampling units were determined based on vegetation and geology characteristics and mapping. Survey methods included flora quadrats, rapid check sites and random meander. Locations of survey quadrats were recorded with handheld GPS unit.

Due to the size of the study area and access limitations, the entire site could not be assessed during the field survey. Therefore, a subset of the study area was ground-truthed and the remaining extent of vegetation communities was mapped by extrapolation and interpretation of aerial imagery.

Flora survey techniques used in the baseline surveys were consistent with the *Northern Territory Guidelines and Field Methodology for Vegetation Survey and Mapping* (Brocklehurst *et al.* 2007). All surveys were conducted in accordance with TPWC Act permits issued to GHD by the Northern Territory Parks and Wildlife Commission.

A detailed description of the field survey methodology for flora and vegetation is contained in Appendix M.

9.3.3 Fauna assessment

Prior to the field investigations, aerial imagery and maps were used as a basis for initial selection of sites for flora and survey. Results from previous survey, where available was used as a basis for preliminary selection of sites for fauna survey.

Sites were then ground-truthed on the first day at the site, to verify their vegetation/habitat characteristics, or to move them to more appropriate locations (e.g., away from heavily disturbed areas). The choice of sites was made in an effort to maximise the likelihood of detecting fauna, including threatened species.

Special consideration was given to habitats that were considered most likely to support threatened fauna species and/or populations listed under the EPBC Act and/or TPWC Act, in accordance with the NT EPA TOR. These included, but were not limited to Black-footed Rock-wallaby (*Petrogale lateralis* MacDonnell Ranges race), Great Desert Skink (*Liopholis kintorei*) and Greater Bilby (*Macrotis lagotis*). These species, and fauna assessment relating to threatened species, are discussed in more detail in Chapter 10.

Weather

The conditions encountered during the surveys were generally acceptable for baseline fauna surveys, particularly daytime temperatures and conditions. However, the wet 24-hour period during 2010 and the relatively cool nights in the early part of the 2015 survey are considered likely to have resulted in less fauna activity than would otherwise be expected.

Survey techniques

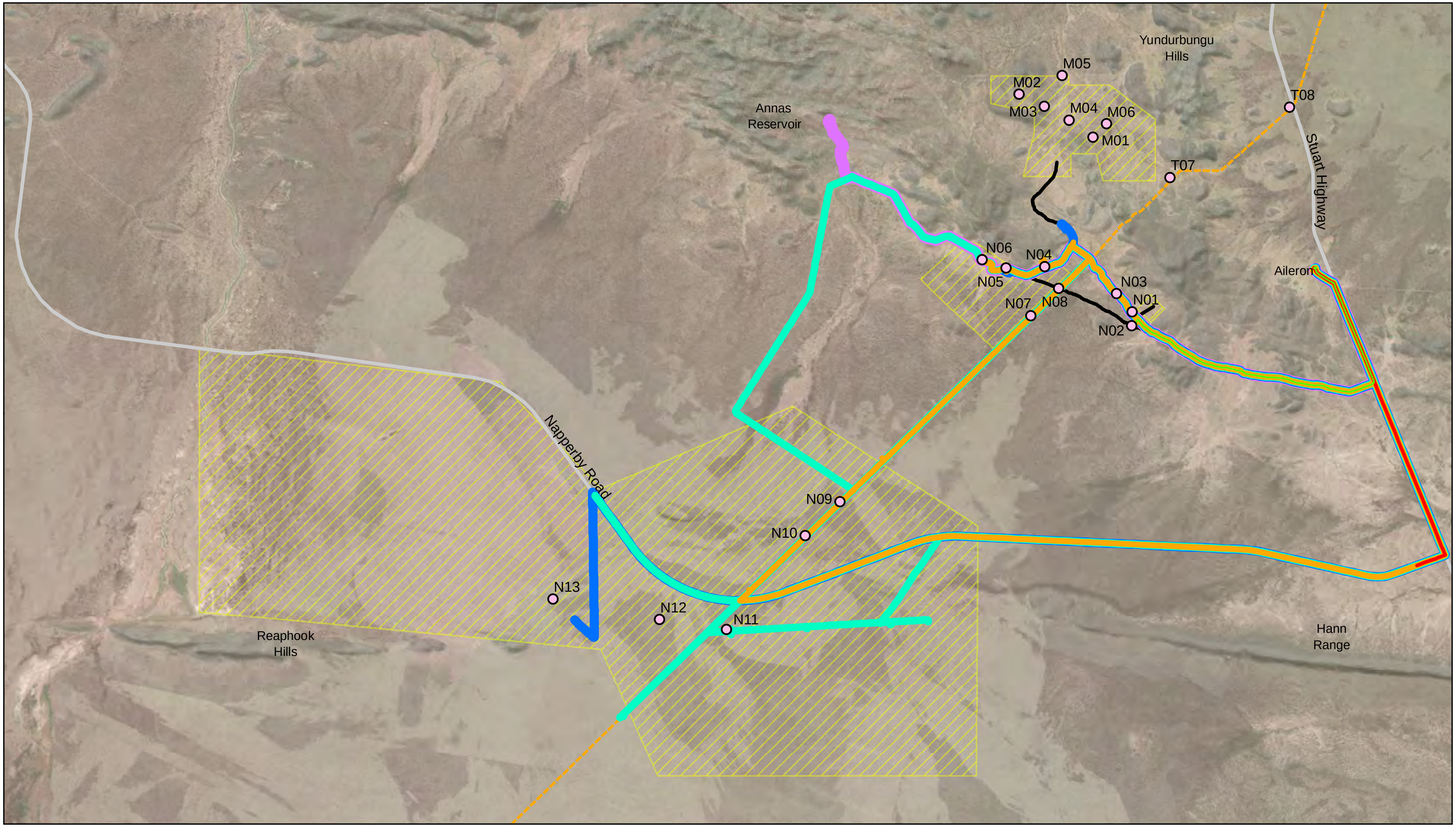
Survey techniques followed the *Standard terrestrial vertebrate survey methods used by the Department of Land Resource Management*. The survey methodologies employed summarised in Table 9-2 and survey effort is illustrated in Figure 9-3 and Figure 9-4.

Table 9-2 Summary of fauna survey effort at sites during the 2010 and 2015 baseline fauna surveys

Survey	2010: Mine Site Area	2010: Haul Route	2015 survey
Survey Type	**6 survey sites (M01 to M06)** **31 Aug to 8 Sept 2010**	**6 transects (T07 to T12)** **2 to 8 Sept 2010**	**13 survey sites (N01 – N13)** **27 April to 3 May 2015**
Habitat assessment	Each survey site – ~1 hour ~25 km of driven tracks ~4 person hours investigating elsewhere	Each survey site – ~1 hour ~60 km of driven tracks ~4 person hours investigating elsewhere	Conducted over approximately two person-hours per site, investigating quadrat area through various survey methods
Pitfall trapping	Sites M01, M04, M05, M06 – 3 nights, 4 trap lines each with one bucket Sites M02 & M03 – 3 nights, 2 trap lines each with one bucket 60 trap-nights	Site T07 – one night, 4 trap lines each with one bucket Site T08 – 4 nights, 4 trap lines each with one bucket 20 trap-nights	Four 10m pitfall traplines, each with one bucket, for ten sites (N01 – N10), checked twice daily for four days and nights 160 trap-nights
Funnel trapping	Sites M01, M04, M05, M06 – 3 nights, 4 trap lines each with 2 funnels (and one bucket) Sites M02 & M03 – 3 nights, 2 trap lines each with 2 funnels (and one bucket) Sites M02 & M03 – 3 nights, 2 trap lines each with 3 funnels 156 trap-nights	Site T07 – one night, 4 trap lines each with 2 funnels (and one bucket) Site T08 – 4 nights, 4 trap lines each with 2 funnels (and one bucket) Sites T09 to T12 – 3 nights, 4 trap lines each with 3 funnels 184 trap-nights	Ten sites (N01 – N10), each with four 10m pitfall traplines, each trapline with two funnels (and one bucket), for four nights. Ten sites (N01 – N10), each with two funnel traplines (two funnels on each) over four nights. Four 10m traplines (each with two funnel traps) for three sites (N11 – N13). 504 trap-nights in total
Elliot trapping	Six sites (M01 – M06) - 20 traps at each, for 3 days and nights, checked twice daily 360 trap-nights	Site T07 - 20 traps for 2 days and one night Site T08 - 20 traps for 4 days and nights, checked twice daily Site T09 to T12 - 20 traps for 3 days and nights, checked twice daily 340 trap nights	Ten sites (N01 – N10), each with 20 baited Elliot traps for four nights. Three sites (N11 – N13), each with 10 Elliot traps for three sites, checked twice daily for four days and nights. 920 trap-nights

Survey	2010: Mine Site Area	2010: Haul Route	2015 survey
Survey Type	**6 survey sites (M01 to M06)** **31 Aug to 8 Sept 2010**	**6 transects (T07 to T12)** **2 to 8 Sept 2010**	**13 survey sites (N01 – N13)** **27 April to 3 May 2015**
"Anabat"®	All six sites (M01 – M06) – one unit for two nights 12 Anabat survey-nights in total	Sites T07, T09 to T11 – one unit for two nights Site T08 and T12 – one unit for one night 10 Anabat survey-nights in total	Eight sites, one survey-night at each (N02, N03, N04, N05, N08, N11, N13, waterhole near gate) 8 survey-nights in total
Remote surveillance cameras	All six sites (M01 – M06) – one unit for three nights 18 camera survey-nights in total	Site T07 – one unit for one night Site T08 – one unit for four nights Site T09 to T12 – one unit for three nights 17 camera survey-nights in total	Eleven units were deployed during the survey, each for at least 30 days and nights (N05, N06, N08, N11 and N13, three cameras at burrow/latrine site, and one along Fence track). At least 330 camera survey-nights in total
Active searches (diurnal)	Each site – two diurnal searches of 10+ minutes each Minimum of 2 hours active searching 8+ scats and 1 bone sample collected and sent for analysis	Each site – two diurnal searches of 10+ minutes each Minimum of 2 hours active searching 3+ scats and one bone collected and sent for analysis	Conducted opportunistically by at least one ecologist at sites and other locations, depending on conditions Minimum of 1.5 hours active searching per site
Active searches (nocturnal)	Each site – one nocturnal search of 10+ minutes each Minimum of 1 hour active searching	Each site – one nocturnal search of 10+ minutes each Minimum of 1 hour active searching	3 x three-hour nocturnal searches by four teams of two people at sites and other locations, including road spotlighting through study area and along existing access tracks Minimum of 72 person-hours active searching in total
Instantaneous bird counts	Each site – one nocturnal bird count; Diurnal counts: M01 - 6; M02, M03, M05 & M06 – 8; M04 - 10 54 instantaneous bird counts in total	Each site – one nocturnal bird count Diurnal counts: T07, T10 & T11 – 6; T08 – 8; T09 & T12 – 5 42 instantaneous bird counts in total	At least four 20 minute diurnal surveys at each site, incorporating 'instantaneous bird counts' 52 bird counts in total.

Survey	2010: Mine Site Area	2010: Haul Route	2015 survey
Survey Type	**6 survey sites (M01 to M06)** **31 Aug to 8 Sept 2010**	**6 transects (T07 to T12)** **2 to 8 Sept 2010**	**13 survey sites (N01 – N13)** **27 April to 3 May 2015**
Opportunistic (incidental) observations	Four zoologists over four 12 hour days during set-up and survey, total survey effort 192 hours 420+ observations recorded	Four zoologists over four 12 hour days during set-up and survey, total survey effort 192 hours 90 observations recorded	Eight zoologists and four rangers over the entire survey period (five 12-hour days during set-up and survey). Minimum of 720 person-hours of opportunistic observation.
Snail searches	Two zoologists targeting snail collection in areas of suitable habitat on two days (5-6 Sept 2010), plus opportunistically at other times. Minimum of 4 hours active searching	Four zoologists targeting snail collection in areas of suitable habitat on one day (7 Sept 2010), plus opportunistically at other times. Minimum of 4 hours active searching	Assessed / Collected opportunistically. Snails sent to NT Museum.



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0 2 4 6 8

Kilometres

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

N

LEGEND

- Fauna Sites
- Roads
- Gas Pipeline
- Access Roads

Survey Tracks

- Day 1
- Day 2
- Day 3
- Day 4
- Day 5
- Day 6
- Study Area

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2015 Baseline fauna survey effort nocturnal coverage of study area

Figure 9-3

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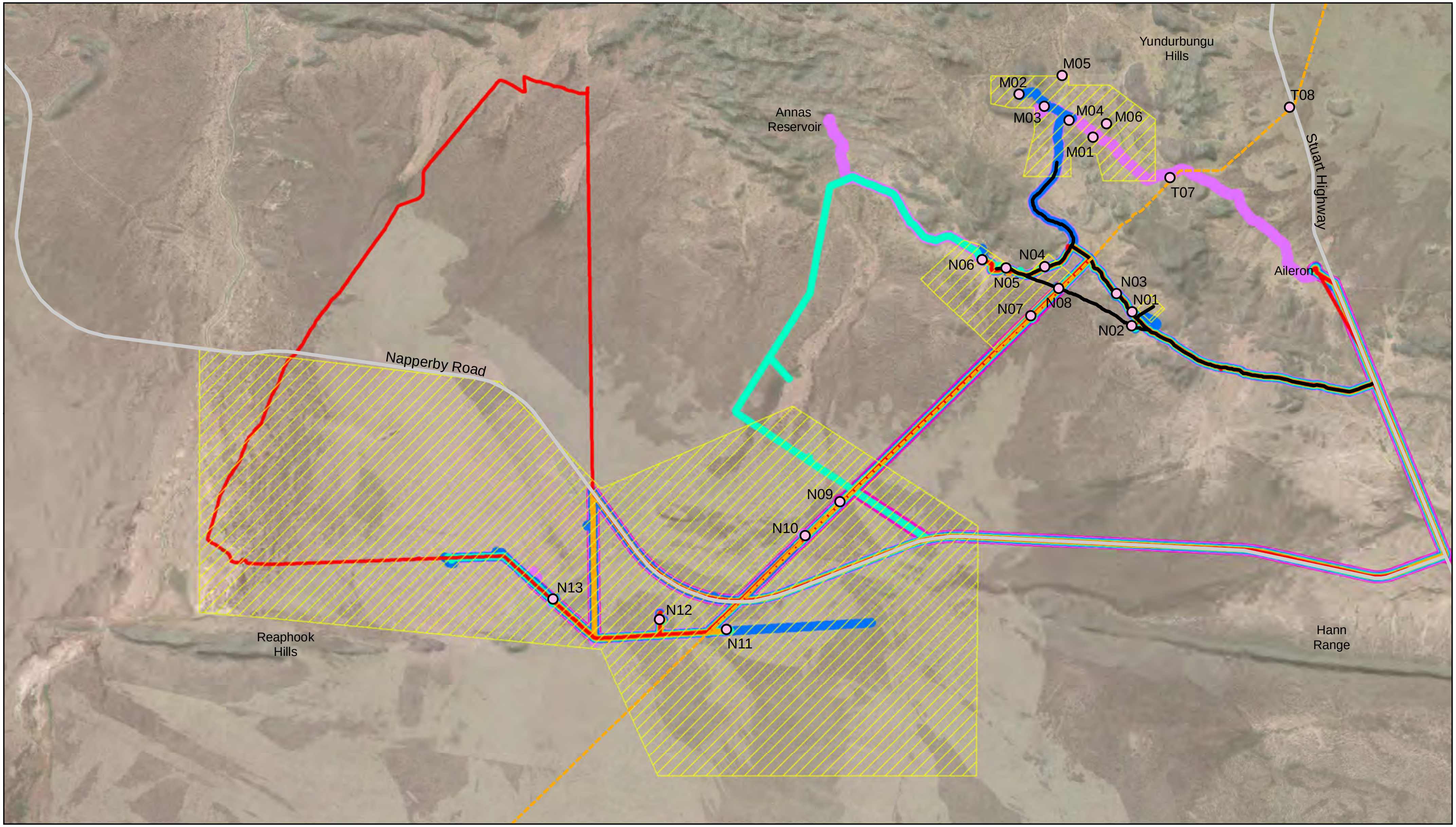
Level 5 66 Smith Street Darwin NT 0800 Australia T 61 8 8982 0100 F 61 8 8981 1075 E drwmail@ghd.com W www.ghd.com

Data source: GA - Imagery (2008), Roads, Gas Pipeline (2015). GHD - Fauna Survey Sites, Proposed Mine Site, Proposed Treatment Plant, Proposed Accommodation Village, Borefield Area (2015). Created by: CM



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0 2 4 6 8

Kilometres

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

N

LEGEND

- Fauna Sites
- Roads
- Gas Pipeline
- Access Roads

Survey Tracks

- Day 1
- Day 2
- Day 3
- Day 4
- Day 5
- Day 6
- Day 7
- Study Area

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Revision	0
Date	18 Mar 2016

2015 Baseline fauna survey effort
diurnal coverage of study area

Figure 9-4

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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: GA - Imagery (2008), Roads, Gas Pipeline (2015). GHD - Fauna Survey Sites, Proposed Mine Site, Proposed Treatment Plant, Proposed Accommodation Village, Borefield Area (2015). Created by: CM

9.4 Results – flora and vegetation

9.4.1 Desktop assessment

The desktop assessment identified the following:

- There are no records of threatened flora species listed under the TPWC Act in the locality however there are six near threatened species, five species endemic to the Northern Territory and eight species recorded as being data deficient.
- There have been 19 exotic species recorded within the locality.
- There are ten threatened plant taxa known to occur in the Burt Plain Bioregion however based on an assessment of habitats within the study area it is unlikely that any of these species would occur in the study area.
- Previous surveys by Low Ecological Services (2007) recorded 185 flora species, of which none are listed as having conservation significance under the EPBC or TPWC Acts.
- The Northern Territory Government database (DRLM 2013) identifies four National Vegetation Information System vegetation types within the study area:
  - Corymbia low woodland/Acacia tall open shrubland/Eragrostis low open tussock grassland
  - Eucalyptus low open woodland/Acacia mid open shrubland/+Triodia low hummock grassland
  - Acacia tall open shrubland/Eragrostis low tussock grassland
  - Acacia mid open mallee woodland/Acacia mid sparse shrubland/+Triodia low hummock grassland.
- The PMST results did not identify any flora species listed under the EPBC Act that are known or predicted to occur in the locality.
- No EPBC Act-listed Threatened Ecological Communities are known or predicted to occur within or near the study area. Only one ecological community is listed in the Northern Territory as threatened under the EPBC Act (Arnhem Plateau Sandstone Shrubland Complex), and this does not occur within or near the study area.
- There are 67 sites of conservation significance across the Northern Territory; none of these occur within or near the study area.

9.4.2 Flora and vegetation survey

A combined total of 326 flora species, comprising 319 native species and 15 exotic species were recorded within the study area during the 2011 and 2015 survey periods.

The Poaceae (grass family, 73 species, 67 native; 6 exotic), Fabaceae (pea family, 40 species, 39 native, one exotic), Chenopodiaceae (32 native species) and Malvaceae (25 native species) were the most species-rich families recorded.

Flora species recorded within the study area and their associated vegetation communities are relatively common in the region with the exception of a few species. No threatened plants were recorded within the study area. Three species recorded within the study area are listed as near threatened (NT) and three species are listed as data deficient under the TPWC Act. An additional 11 species are noted to have bioregional significance.

The full list of plant species recorded within the study area is presented in Appendix M.

Vegetation communities

A total of 14 vegetation communities were identified within the study area. These vegetation communities each display a degree of variation which is to be expected given the influence of differing geology, soils, hydrology, fire regimes and grazing pressures. Despite these variations these communities have been defined based on similarities in landscape position, floristics, vegetation structure and patterns.

The dominant vegetation types within the study area are Mulga shrublands, which occur on alluvial fans and plains containing clayey red earths and Triodia hummock grasslands which grow on sandy plains. Vegetation across the study area is generally in good condition with little anthropologic disturbance and high species richness.

In more fertile riparian areas and associated floodplains there is clear evidence of impacts associated with cattle grazing including weed invasion, reduction in ground cover species richness and soil erosion. In particular, there is a high abundance of the invasive grass *Cenchrus ciliaris* (Buffel Grass). There are also several areas that have been cleared within the mine site and borefields area during geotechnical and hydrological investigations at these sites.

Vegetation communities identified and mapped within the study area and their relative abundance are summarised in Table 9-3 and their distributions shown in Figure 9-5.

A detailed description of each vegetation community present within the study area is provided in Appendix M.

Adjacent to the access road to the proposed accommodation village is a small Coolabah Swamp. Although this vegetation is not within the project site it has been included in the assessment as there is potential for this wetland to be indirectly impacted by the project.

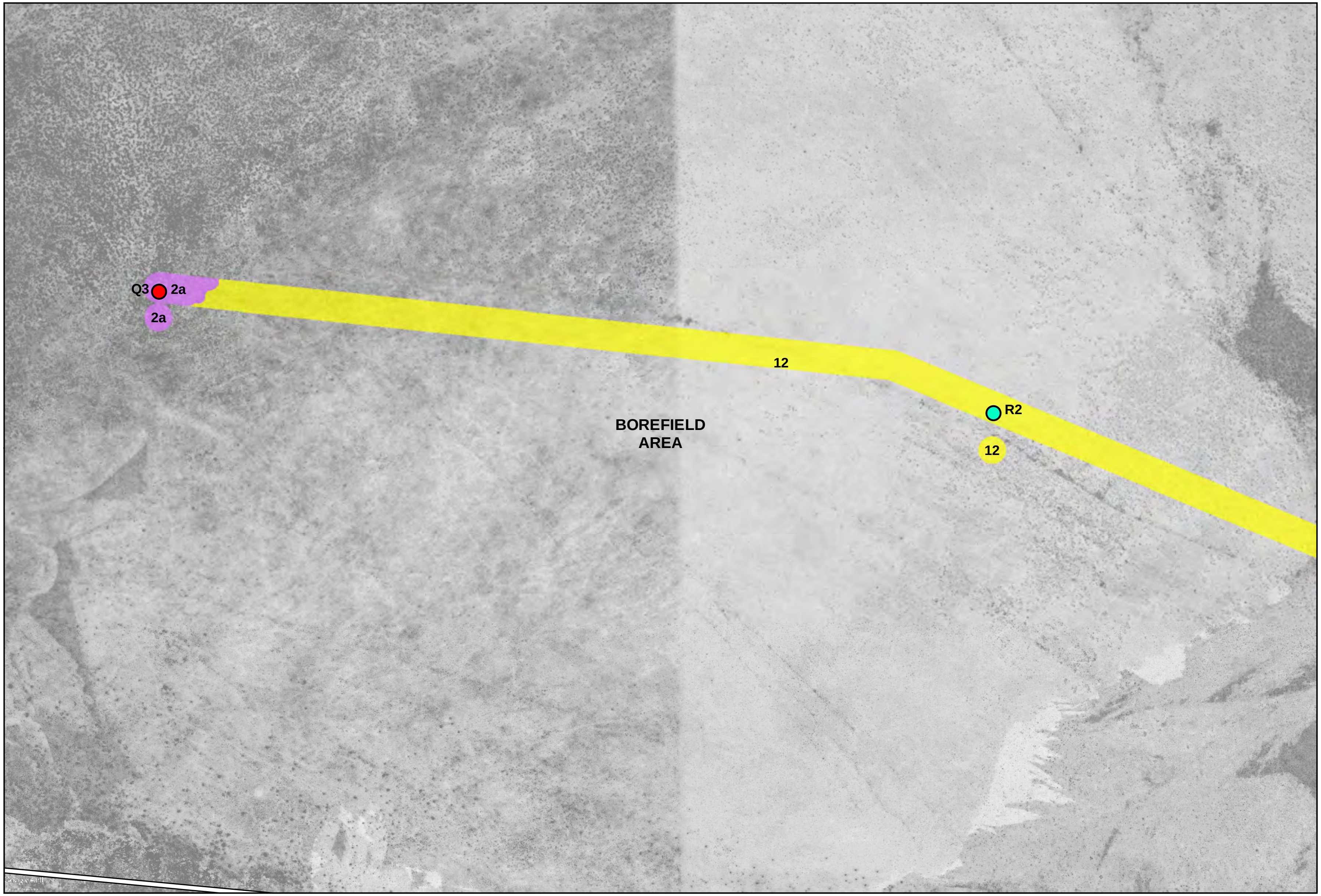
Table 9-3 Comparisons of vegetation communities within study area with Albrecht and Pitts (2004) vegetation types

Nolans Project 2010/11 and 2015 mapping		Area (ha)	% of study area	Albrecht and Pitts (2004) mapping	
Vegetation type	**Description**			**Vegetation type**	**Description**
1	Riparian woodland along water courses and drainage channels	261.1	4.6	22	Large sandy red gum creeklines
2a	Mulga shrubland on sandy red earths over spinifex	46.4	0.8	16	Mulga in valleys with red earth soils
2b	Mulga shrubland on sandy red earths over tussock grasses	1756.8	30.8	16	Mulga in valleys with red earth soils
2c	Mulga shrubland on sandy red earths over chenopods	41.6	0.6	16	Mulga in valleys with red earth soils
3a	Mixed woodland over tussock grasses on alluvial plains	780.2	13.7	17	Ironwood and fork-leaved corkwood on alluvial flats
3b	Mixed Woodland over spinifex on alluvial plains	31.2	0.5	N/A	Not described by Albrecht and Pitts 2004
3c	Mixed Woodland over a highly disturbed understorey dominated by *Cenchrus ciliaris*	21.8	0.4	N/A	Not described by Albrecht and Pitts 2004
4	*Triodia schinzii* hummock grassland on red clayey sands	0*	0*	N/A	Not described by Albrecht and Pitts 2004

5	Hakea/Senna shrubland on calcareous alluvial plains and low rises	232.5	4.1	N/A	Not described by Albrecht and Pitts 2004
6	Eucalyptus (mallee)/*Acacia kempeana* shrubland with Triodia on rocky slopes	59.9	1.0	1	Hillside spinifex and mallee on quartzite slopes
7	Acacia/Triodia shrubland on rocky outcrops	226.6	4.0	1 & 3	Hillside spinifex and mallee on quartzite slopes; hillside spinifex on hills of granite, gneiss or schist
8	Acacia/Senna shrubland on rocky gneiss or schist outcrops with no spinifex	3.2	0.05	4	Witchetty Bush and/or Mulga on rocky hills of granite, gneiss or schist
9	*Acacia kempeana* and/or Mulga shrubland on gravel	126.3	2.2	5	Witchetty Bush and/or Mulga on gravelly rises of granite, gneiss, schist or quartz
10	Claypans with chenopods and herbs	0.3	0.005	25	Claypans often with a fringing sandy herbfield
11	Cottonbush chenopod shrubland on highly erodible duplex soils	13.5	0.2	18	Needlebush and Cottonbush on erodible sandy-clay flats
12	*Triodia basedowii* hummock grassland on sand plains	851.9	14..9	14	Rises of loose sand with hard spinifex

13	Senna shrubland on quartz	16.6	0.3	8	Whitewood and Senna on gravelly rises associated with silcrete outcrop
14	Coolabah swamp associated with claypans	2.6	0.04	24	Coolabah associated with claypans
2a/2b	Mulga shrubland on sand red earths over tussock grasses / Mulga shrubland on sandy red earths over spinifex	1155.1	20.3	16	Mulga in valleys with red earth soils
2b/3a	Mulga shrubland on sandy red earths over tussock grasses / Mixed woodland over tussock grasses on alluvial plains	11.8	0.2	N/A	Not described by Albrecht and Pitts 2004
3a/12	Mixed woodland over tussock grasses on alluvial plains / Cottenbush chenopod shrubland on highly erodible duplex soils	20.2	0.4	N/A	Not described by Albrecht and Pitts 2004
3b/2b	Mixed woodland over spinifex on alluvial plains / Mulga shrubland on sandy red earths over tussock grasses.	25.6	0.4	N/A	Not described by Albrecht and Pitts 2004
TOTAL		**5704 ha**			

*This vegetation type was recorded only along the transport corridor that is no longer part of the study area.



Vegetation Community

1	Riparian woodland along water courses and drainage channels
2a	Mulga shrubland on sandy red earths over spinifex
2a / 2b	Mulga shrubland on sandy red earths over tussock grasses / Mulga shrubland on sandy red earths over spinifex
2b	Mulga shrubland on sandy red earths over tussock grasses
2b / 3 a	Mulga shrubland on sandy red earths over tussock grasses / Mixed woodland over tussock grasses on alluvial plains
2c	Mulga shrublands on sandy red earths over chenopods
3	Mixed Woodland over tussock grasses
3a / 12	Mixed woodland over tussock grasses on alluvial plains / Cottonbush chenopod shrubland on highly erodible duplex soils
3b	Mixed woodland over spinifex on alluvial plains
3b / 2b	Mixed woodland over spinifex on alluvial plains / Mulga shrubland on sandy red earths over tussock grasses
3c	Mixed woodland over a highly disturbed understorey dominated by *Cenchrus ciliaris*
5	Hakea/Senna Shrubland on Calcareous Alluvial Plains and Low Rises
6	Eucalyptus (mallee)/*Acacia kempeana*/Triodia Shrubland on Rocky Slopes
7	Acacia/Triodia shrubland on rocky outcrops
8	Acacia/Senna shrubland on rocky gneiss or schist outcrops with no spinifex
9	Acacia kempeana and /or mulga shrubland on gravel
10	Claypans with chenopods and herbs
11	Cottonbush chenopod shrubland on highly erodible duplex soils
12	*Triodia basedowii* hummock grassland on sandplains
13	Senna shrubland on quartz
14	Coolabah swamp associated with claypans

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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

- Checksites
- Quadrats 2015
- Quadrats 2011
- Existing Roads
- Site Boundaries

6 5 7 8 4 1 2 3

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Vegetation communities within the Study area Figure 9-5 (Page 1 of 8):

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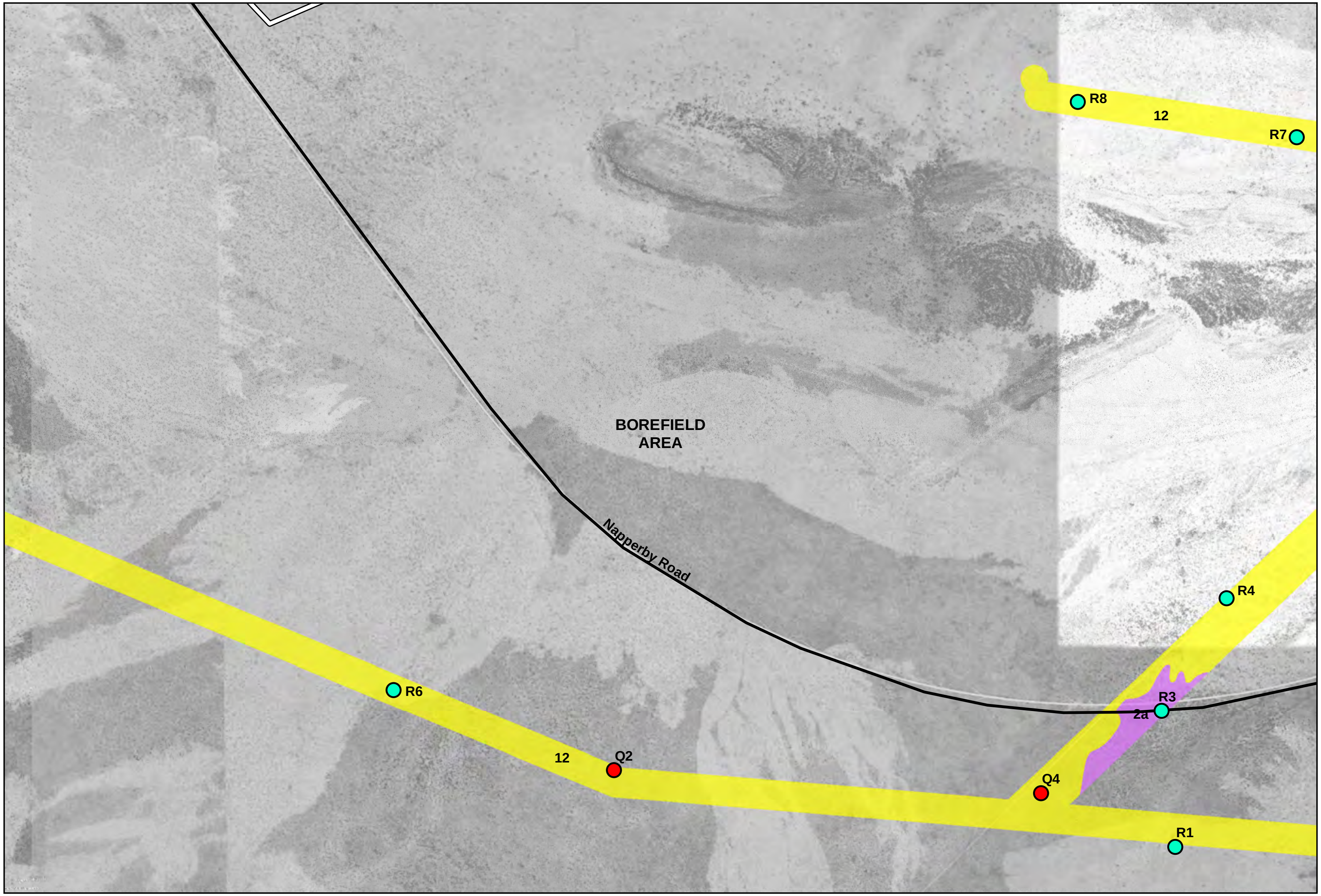
Level 5 66 Smith Street Darwin NT 0800 Australia T 61 8 8982 0100 F 61 8 8981 1075 E drwmail@ghd.com W www.ghd.com

Data source: Google Earth Pro - Imagery (Date extracted: 16/06/2015). GA - Roads (2015). GHD - Vegetation Data (2015). Created by: CM



Vegetation Community

	1	Riparian woodland along water courses and drainage channels
	2a	Mulga shrubland on sandy red earths over spinifex
	2a / 2b	Mulga shrubland on sandy red earths over tussock grasses / Mulga shrubland on sandy red earths over spinifex
	2b	Mulga shrubland on sandy red earths over tussock grasses
	2b / 3 a	Mulga shrubland on sandy red earths over tussock grasses / Mixed woodland over tussock grasses on alluvial plains
	2c	Mulga shrublands on sandy red earths over chenopods
	3	Mixed Woodland over tussock grasses
	3a / 12	Mixed woodland over tussock grasses on alluvial plains / Cottonbush chenopod shrubland on highly erodible duplex soils
	3b	Mixed woodland over spinifex on alluvial plains
	3b / 2b	Mixed woodland over spinifex on alluvial plains / Mulga shrubland on sandy red earths over tussock grasses
	3c	Mixed woodland over a highly disturbed understorey dominated by *Cenchrus ciliaris*
	5	Hakea/Senna Shrubland on Calcareous Alluvial Plains and Low Rises
	6	Eucalyptus (mallee)/*Acacia kempeana*/Triodia Shrubland on Rocky Slopes
	7	Acacia/Triodia shrubland on rocky outcrops
	8	Acacia/Senna shrubland on rocky gneiss or schist outcrops with no spinifex
	9	Acacia kempeana and /or mulga shrubland on gravel
	10	Claypans with chenopods and herbs
	11	Cottonbush chenopod shrubland on highly erodible duplex soils
	12	*Triodia basedowii* hummock grassland on sandplains
	13	Senna shrubland on quartz
	14	Coolabah swamp associated with claypans

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Metres

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

N

LEGEND

- Checksites
- Quadrats 2015
- Quadrats 2011
- Existing Roads
- Site Boundaries

6 5 7 8 4 1 2 3

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Vegetation communities within the Study area Figure 9-5 (Page 2 of 8):

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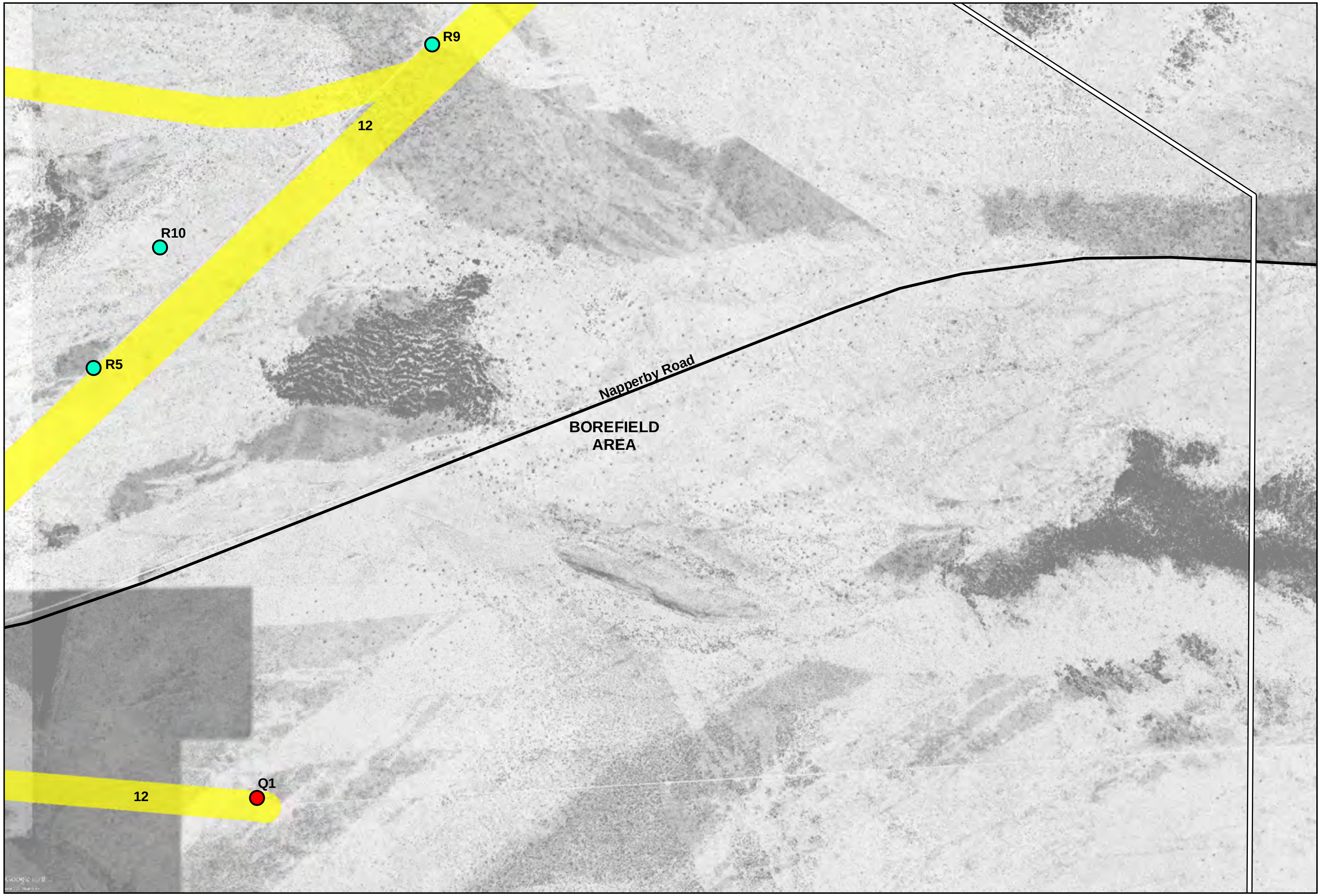
Level 5 66 Smith Street Darwin NT 0800 Australia T 61 8 8982 0100 F 61 8 8981 1075 E drwmail@ghd.com W www.ghd.com

Data source: Google Earth Pro - Imagery (Date extracted: 16/06/2015). GA - Roads (2015). GHD - Vegetation Data (2015). Created by: CM



Vegetation Community

1	Riparian woodland along water courses and drainage channels
2a	Mulga shrubland on sandy red earths over spinifex
2a / 2b	Mulga shrubland on sandy red earths over tussock grasses / Mulga shrubland on sandy red earths over spinifex
2b	Mulga shrubland on sandy red earths over tussock grasses
2b / 3 a	Mulga shrubland on sandy red earths over tussock grasses / Mixed woodland over tussock grasses on alluvial plains
2c	Mulga shrublands on sandy red earths over chenopods
3	Mixed Woodland over tussock grasses
3a / 12	Mixed woodland over tussock grasses on alluvial plains / Cottonbush chenopod shrubland on highly erodible duplex soils
3b	Mixed woodland over spinifex on alluvial plains
3b / 2b	Mixed woodland over spinifex on alluvial plains / Mulga shrubland on sandy red earths over tussock grasses
3c	Mixed woodland over a highly disturbed understorey dominated by *Cenchrus ciliaris*
5	Hakea/Senna Shrubland on Calcareous Alluvial Plains and Low Rises
6	Eucalyptus (mallee)/*Acacia kempeana*/Triodia Shrubland on Rocky Slopes
7	Acacia/Triodia shrubland on rocky outcrops
8	Acacia/Senna shrubland on rocky gneiss or schist outcrops with no spinifex
9	Acacia kempeana and /or mulga shrubland on gravel
10	Claypans with chenopods and herbs
11	Cottonbush chenopod shrubland on highly erodible duplex soils
12	*Triodia basedowii* hummock grassland on sandplains
13	Senna shrubland on quartz
14	Coolabah swamp associated with claypans

1:40,000 @ A4

0 250 500 750 1,000

Metres

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

N

LEGEND

- Checksites
- Quadrats 2015
- Quadrats 2011
- Existing Roads
- Site Boundaries

6 5 7 8 4 1 2 3

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Vegetation communities within the Study area Figure 9-5 (Page 3 of 8):

G:\43\22301\GIS\Maps\4322301_029_VegetationMappingQuadrats.mxd

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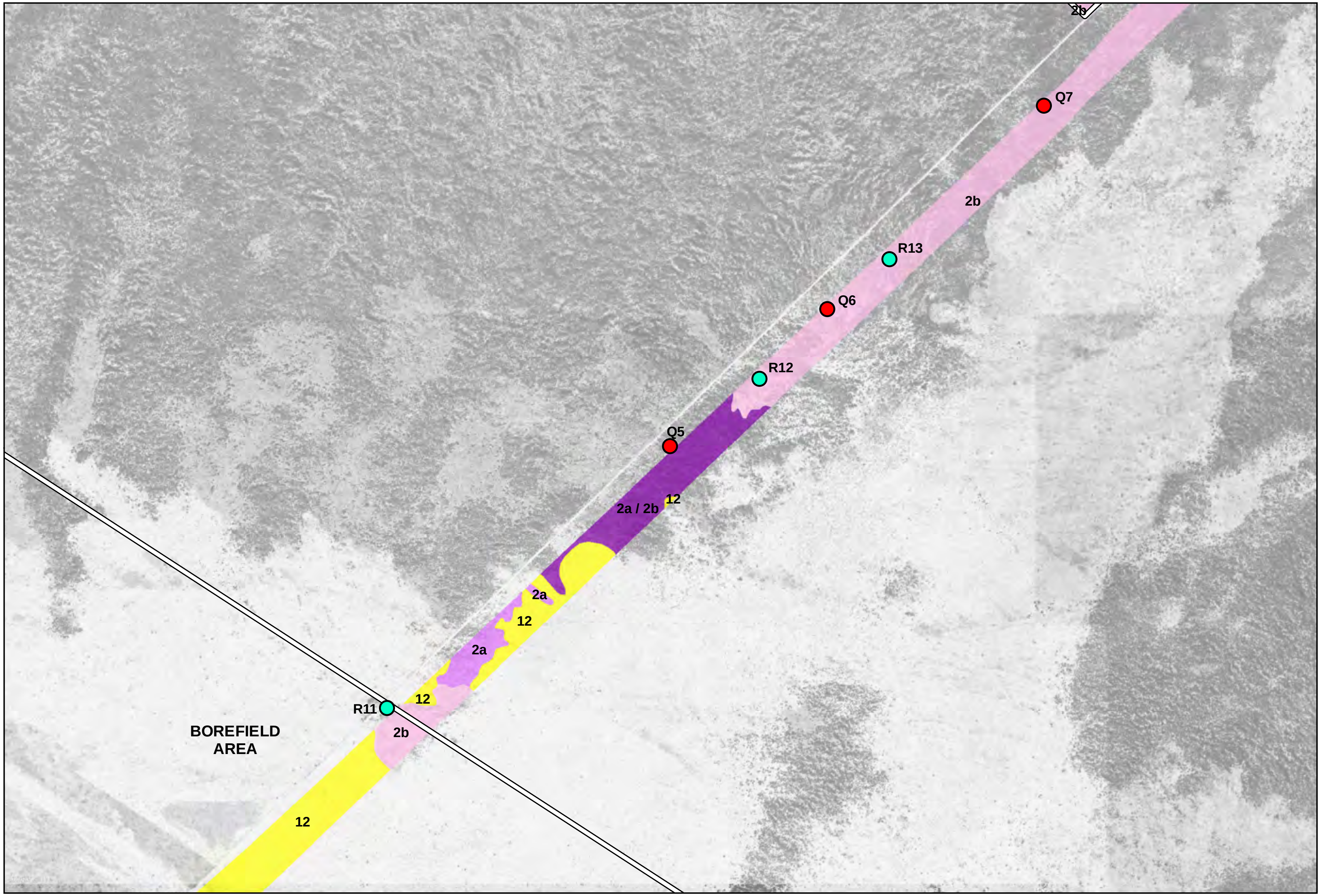

Vegetation Community

1	Riparian woodland along water courses and drainage channels
2a	Mulga shrubland on sandy red earths over spinifex
2a / 2b	Mulga shrubland on sandy red earths over tussock grasses / Mulga shrubland on sandy red earths over spinifex
2b	Mulga shrubland on sandy red earths over tussock grasses
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3	Mixed Woodland over tussock grasses
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3b / 2b	Mixed woodland over spinifex on alluvial plains / Mulga shrubland on sandy red earths over tussock grasses
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14	Coolabah swamp associated with claypans

1:40,000 @ A4

0 250 500 750 1,000

Metres

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

N

LEGEND

- Checksites
- Quadrats 2015
- Quadrats 2011
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- Site Boundaries

6 5 7 8 4 1 2 3

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Vegetation communities within the Study area Figure 9-5 (Page 4 of 8):

G:\43\22301\GIS\Maps\4322301_029_VegetationMappingQuadrats.mxd

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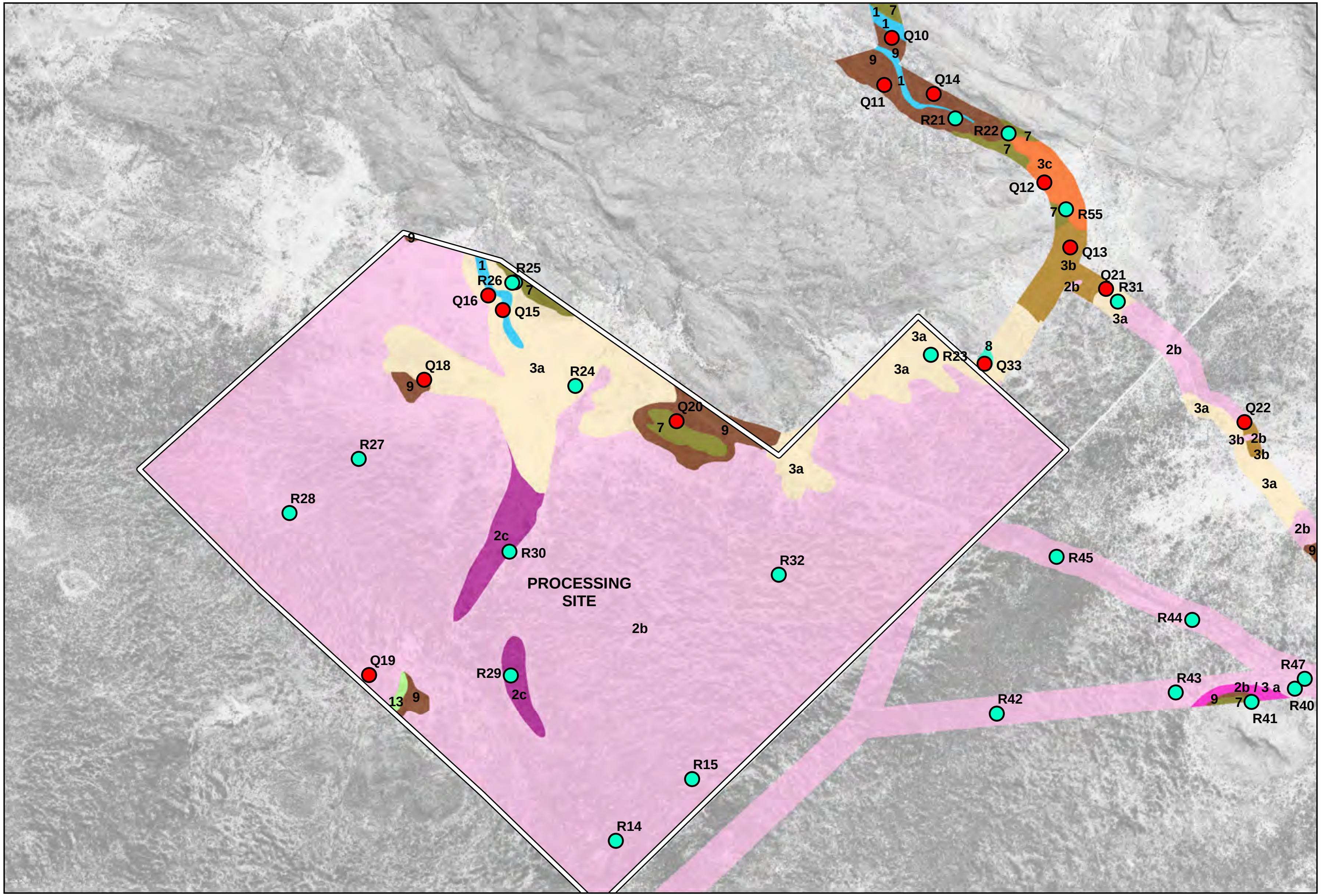

Vegetation Community

	1	Riparian woodland along water courses and drainage channels
	2a	Mulga shrubland on sandy red earths over spinifex
	2a / 2b	Mulga shrubland on sandy red earths over tussock grasses / Mulga shrubland on sandy red earths over spinifex
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	13	Senna shrubland on quartz
	14	Coolabah swamp associated with claypans

1:40,000 @ A4

0 250 500 750 1,000

Metres

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

N

LEGEND

Checksites — Existing Roads
Quadrats 2015 — Site Boundaries
Quadrats 2011

6 5 7 8 4 1 2 3

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Vegetation communities within the Study area Figure 9-5 (Page 5 of 8):

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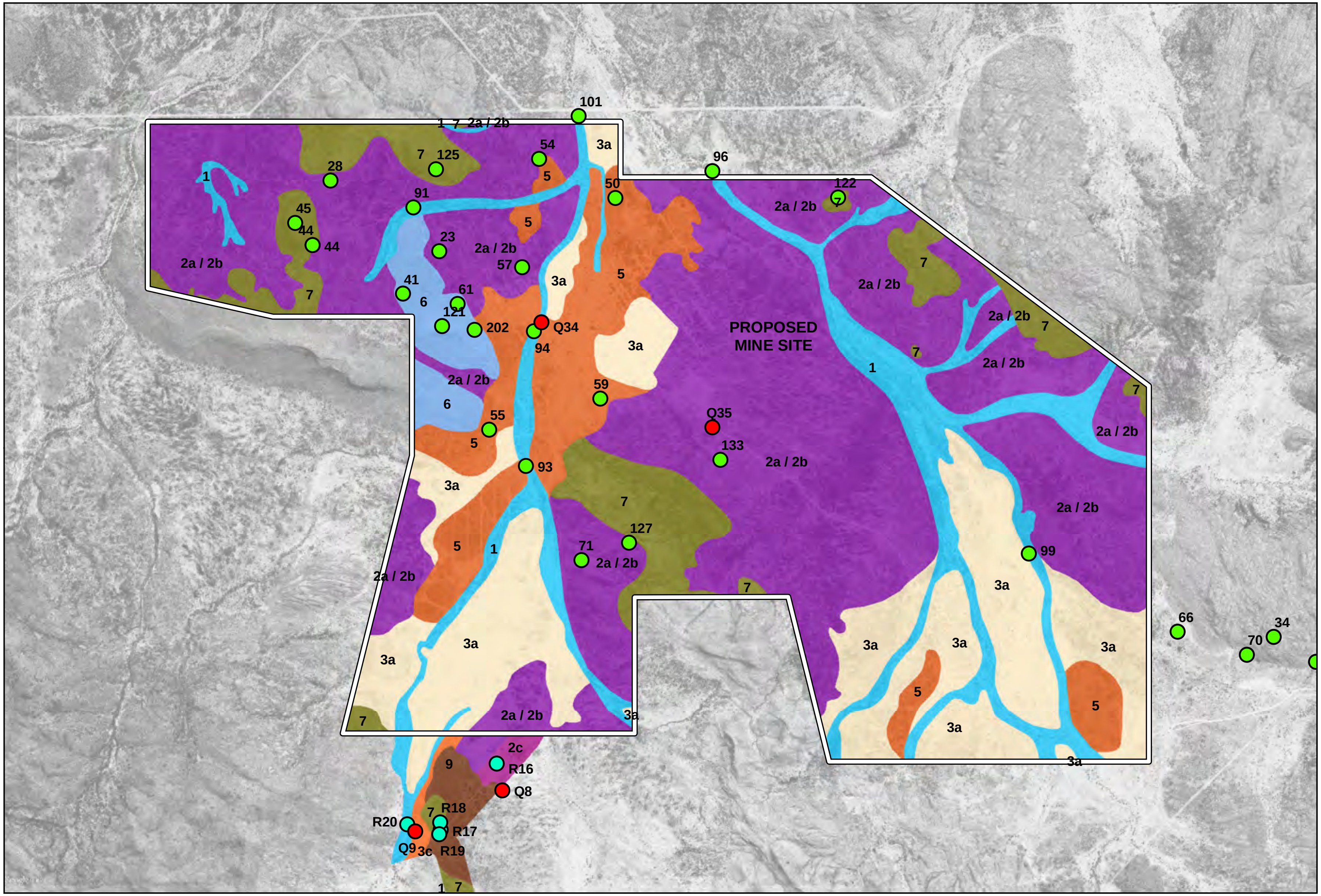

Vegetation Community

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1:40,000 @ A4

0 250 500 750 1,000

Metres

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

N

LEGEND

- Checksites
- Quadrats 2015
- Quadrats 2011
- Existing Roads
- Site Boundaries

6 5 7 8 4 1 2 3

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Vegetation communities within the Study area Figure 9-5 (Page 6 of 8):

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Vegetation Community

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0 250 500 750 1,000

Metres

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Horizontal Datum: GDA 1994
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LEGEND

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Vegetation communities within the Study area Figure 9-5 (Page 7 of 8):

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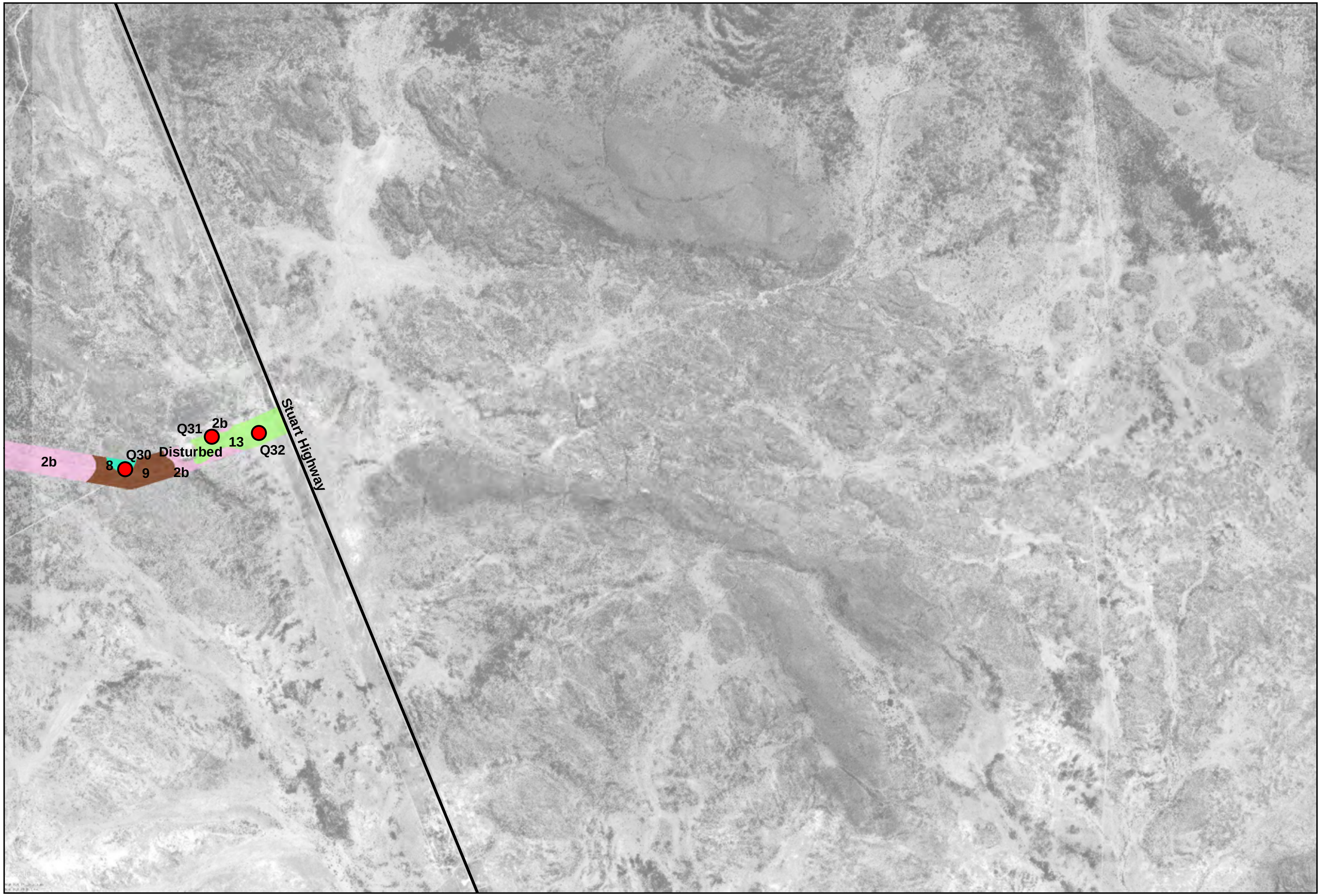

Vegetation Community

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1:40,000 @ A4

0 250 500 750 1,000

Metres

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

N

LEGEND

- Checksites
- Quadrats 2015
- Quadrats 2011
- Existing Roads
- Site Boundaries

6 5 7 8 4 1 2 3

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Vegetation communities within the Study area Figure 9-5 (Page 8 of 8):

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Vegetation condition

The study area contains a high level of vegetation/habitat diversity including hummock grasslands, shrublands, woodlands and riparian corridors. This is largely due to the wide range of landforms (watercourses, alluvial plains, aeolian plains, alluvial foothill fans, rocky hills), particularly within the mine site and processing plant area.

Species richness within the study area is relatively high with highest diversity recorded in areas of rocky outcrops and mulga shrublands although plant species were well represented across the study area.

The native vegetation in the study area is in good condition. This conclusion is based on the high local-scale species richness, the presence of multiple age classes of woody species, the low incidence of exotic species in many of the vegetation communities and the abundant flowering activity noted in *Triodia* and *Senna* populations during the 2010 surveys. This flowering activity was presumably in response to the above average rainfall received in the months leading up to the survey.

Vegetation clearing and fire

The vegetation is largely intact with minimal vegetation lost due to clearing although there is some evidence of native vegetation clearing associated with mineral and geotechnical exploration in the vicinity of Nolans Bore and within the borefields area. Small amounts of vegetation clearing have also occurred for construction of Darwin to Alice Springs gas pipeline and unsealed tracks throughout the study area as well as livestock management.

There is some evidence of recent fire within the study area in 2015, in particular vegetation communities 3 and 7 (Mixed woodlands on alluvial plains and Acacia/Triodia shrubland on rocky outcrops).

Exotic species

A total of fourteen exotic species were recorded during the field survey (refer to Table 9-4 and Figure 9-6). With the exception of *Cenchrus ciliaris (*Buffel Grass) these species generally occurred in very small numbers across the study area.

One of these species (*Tribulus terrestris*) is listed as a Class B (spread must be controlled) and Class C (not to be introduced to the NT) noxious weeds under the *Weeds Management Act* (WM Act). This species was found in low abundance throughout all vegetation types within the study area. It is likely that this species is spread by cattle and vehicle movement.

Overall there is a low to moderate level of infestation of exotic species within the study area with the most prevalent species being Buffel Grass. This species was recorded predominantly within floodplain and riparian vegetation types and in areas that have been disturbed by cattle and/or by mineral exploration.

Table 9-4 Exotic species recorded within the study area

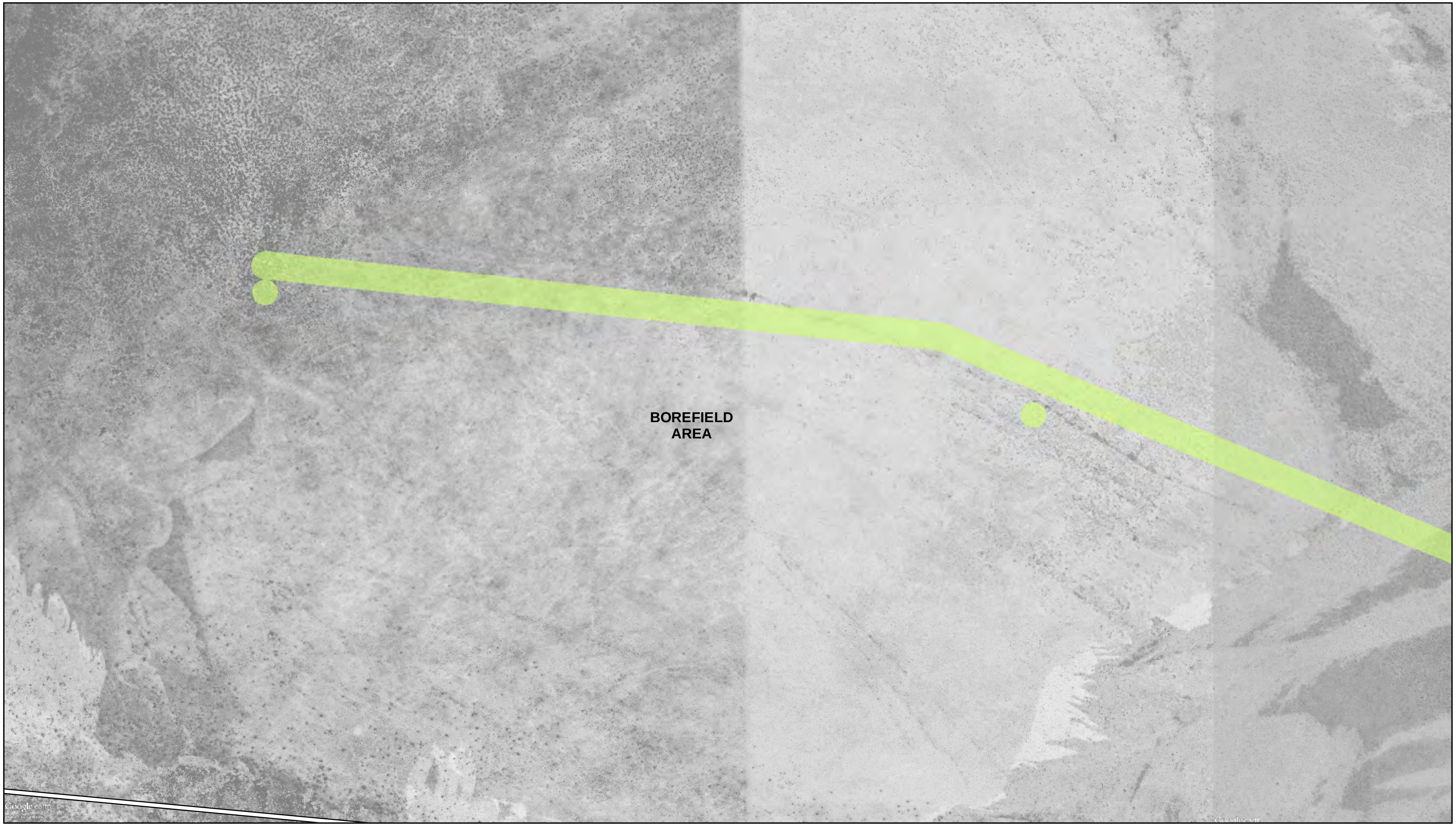
Species Name	Common Name	Legislative status (WM Act)
Tribulus terrestris s.lat.	Caltrop	Listed as a Class B and Class C Noxious Weed
Bidens bipinnata	Cobblers Pegs	Not listed
Cenchrus ciliaris	Buffel Grass	Not listed
Chloris barbata	Purple-top Chloris	Not listed
Chloris virgata		Not listed
Citrullus lanatus	Paddy Melon	Not listed
Cynodon dactylon var. *dactylon*	Couch Grass	Not listed
Digitaria ciliaris	Summer Grass	Not listed
Eragrostis barrelieri	Pitted Lovegrass	Not listed
Eragrostis trichophora		Not listed
Eragrostis minor	Malvastrum	Not listed
Malvastrum americanum		Not listed
Vachellia farnesiana var. *farnesiana*	Mimosa Bush	Not listed
Sonchus oleraceus	Milk Thistle	Not listed

Buffel Grass invasion has been identified as a major threat to biodiversity within the Burt Plain Bioregion (Neave *et al* 2006). *Cynodon dactylon* (Couch Grass) has also been recognised as a potentially serious environmental weed posing a significant threat to biodiversity in the region (Neave *et al* 2006).

The most abundant and widespread weed throughout the study area was *Cenchrus ciliaris* (Buffel Grass) and although not listed under any of the schedules of the Northern Territory's WM Act Buffel Grass is an invasive weed that is known to spread rapidly in arid and semi-arid regions of Australia (Miller *et al* 2010). Relative covers of Buffel Grass across the study area are shown in Figure 9-6.

Soil disturbance associated with proposed mining activity has the potential to accelerate the spread of Buffel Grass and other exotic species throughout the study area.

Other taxa present within the study area that have been identified as having the potential to impact on biodiversity - although to a significantly lesser degree that Buffel and Couch Grass - include *Malvastrum americanum, Eragrostis barrelieri* and *Eragrostis trichophora* (Neave *et al* 2006). These species are present in low numbers throughout the study area and were confined to riparian areas and associated floodplains.



1:40,000 @ A4

0 250 500 750 1,000

Metres

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

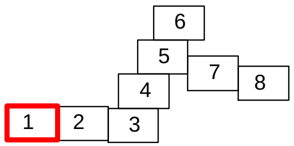
N

LEGEND

- *Eragrostis tricophora*
- Existing Gas Pipeline
- Roads
- Indicative Gas Pipeline Corridor
- Site Boundaries

Buffel Grass (%)

- < 5%
- 6 - 40%
- 41 - 70%
- 71 - 100%



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Buffel grass present in the Study area

Figure 9-6 (Page 1 of 8)

G:\43\22301\GIS\Maps\4322301_030_WeedMapping.mxd

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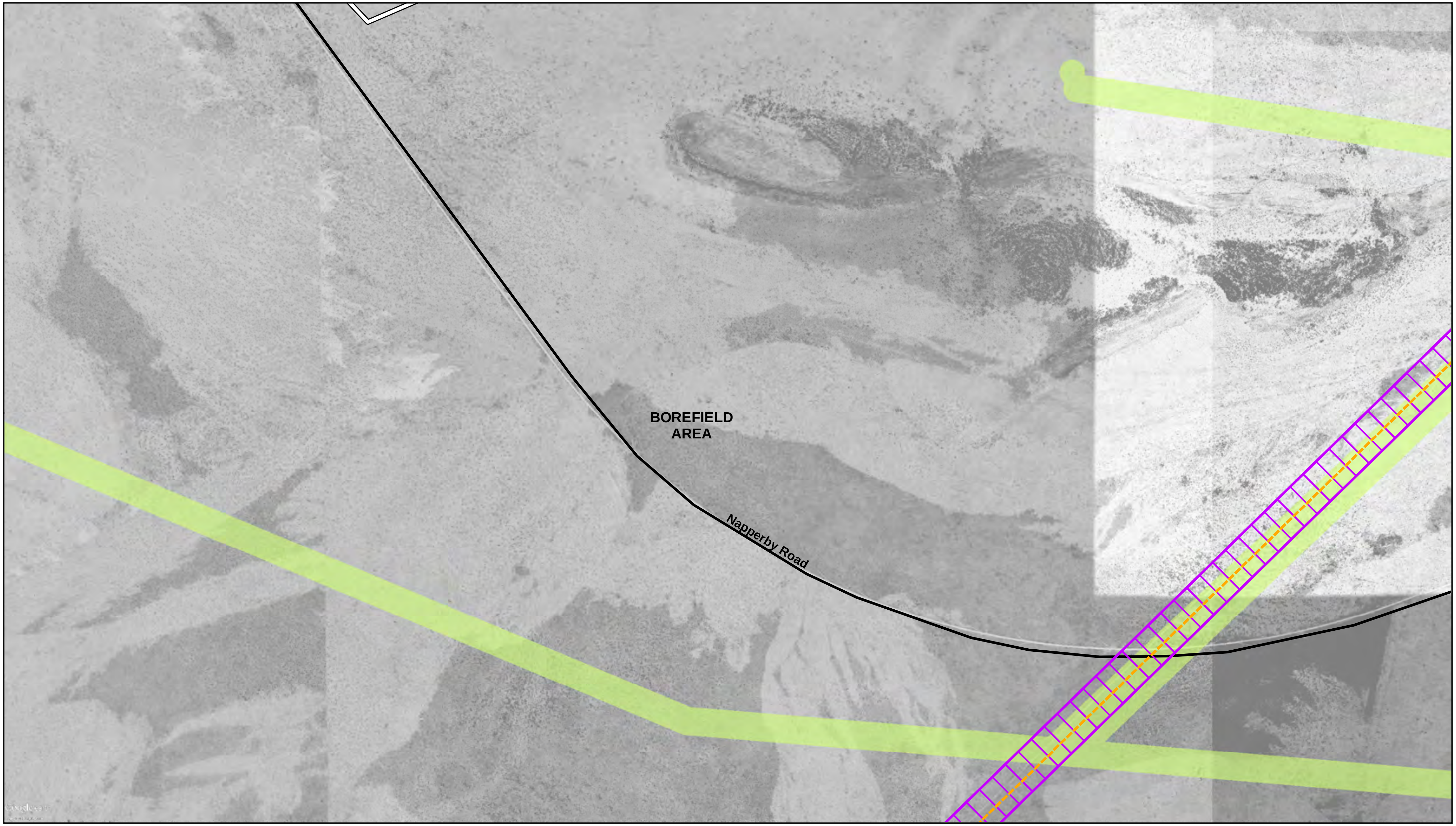

1:40,000 @ A4

0 250 500 750 1,000

Metres

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

N

LEGEND

Eragrostis tricophora

Existing Gas Pipeline

Roads

Indicative Gas Pipeline Corridor

Site Boundaries

Buffel Grass (%)

< 5%

6 - 40%

41 - 70%

71 - 100%

6 5 7 8 4 1 2 3

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Buffel grass present in the Study area

Figure 9-6 (Page 2 of 8)

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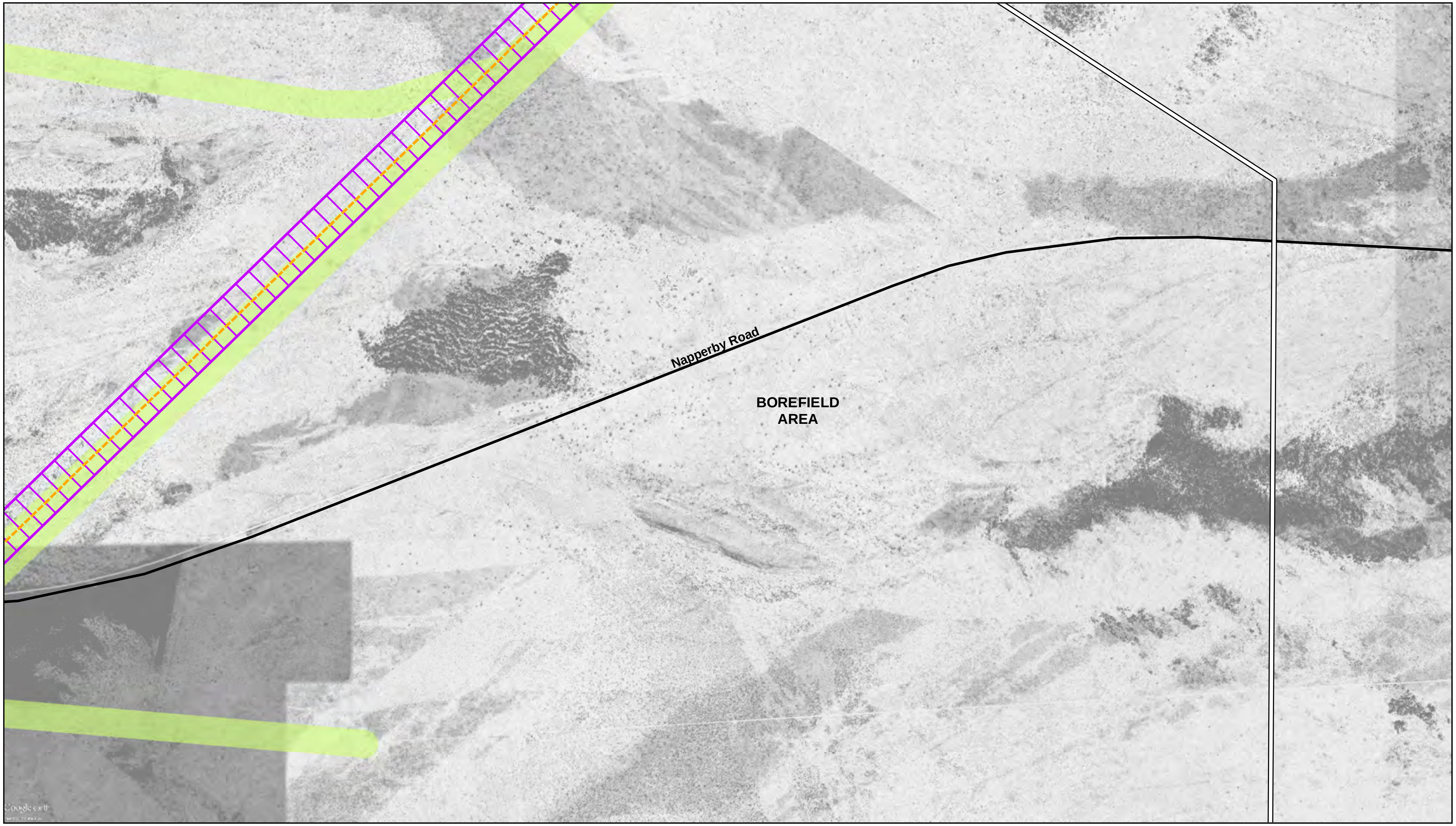

1:40,000 @ A4
0 250 500 750 1,000
Metres

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

N

LEGEND
Eragrostis tricophora
Existing Gas Pipeline
Roads
Indicative Gas Pipeline Corridor
Site Boundaries
Buffel Grass (%)
< 5%
6 - 40%
41 - 70%
71 - 100%

6 5 7 8 4 1 2 3

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Buffel grass present in the Study area

Figure 9-6 (Page 3 of 8)

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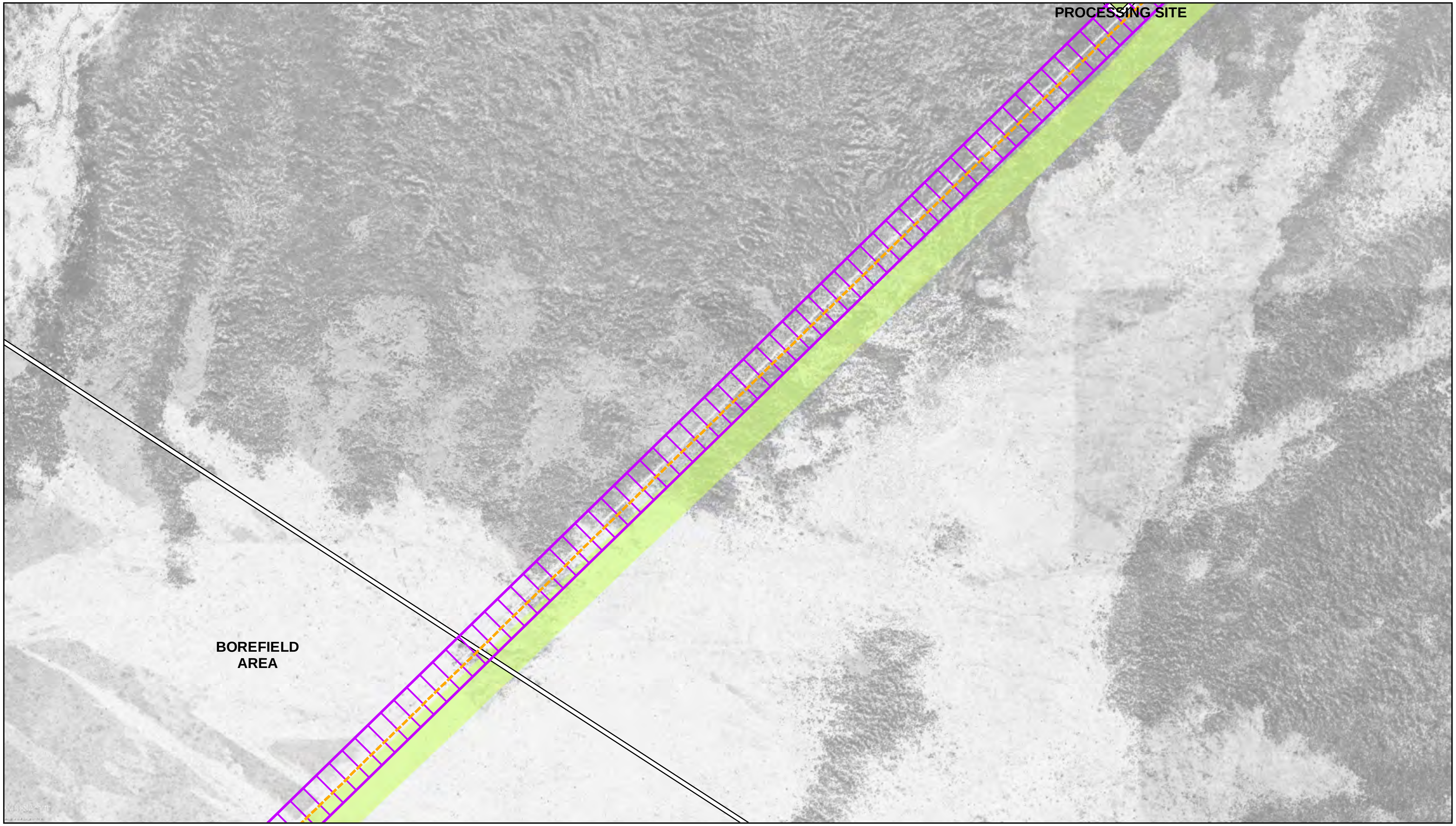

1:40,000 @ A4

0 250 500 750 1,000

Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: GDA 1994
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LEGEND

Eragrostis tricophora
Existing Gas Pipeline
Roads
Indicative Gas Pipeline Corridor
Site Boundaries
Buffel Grass (%)
< 5%
6 - 40%
41 - 70%
71 - 100%

6 5 7 4 8 1 2 3

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Revision 0
Date 18 Mar 2016

Buffel grass present in the Study area

Figure 9-6 (Page 4 of 8)

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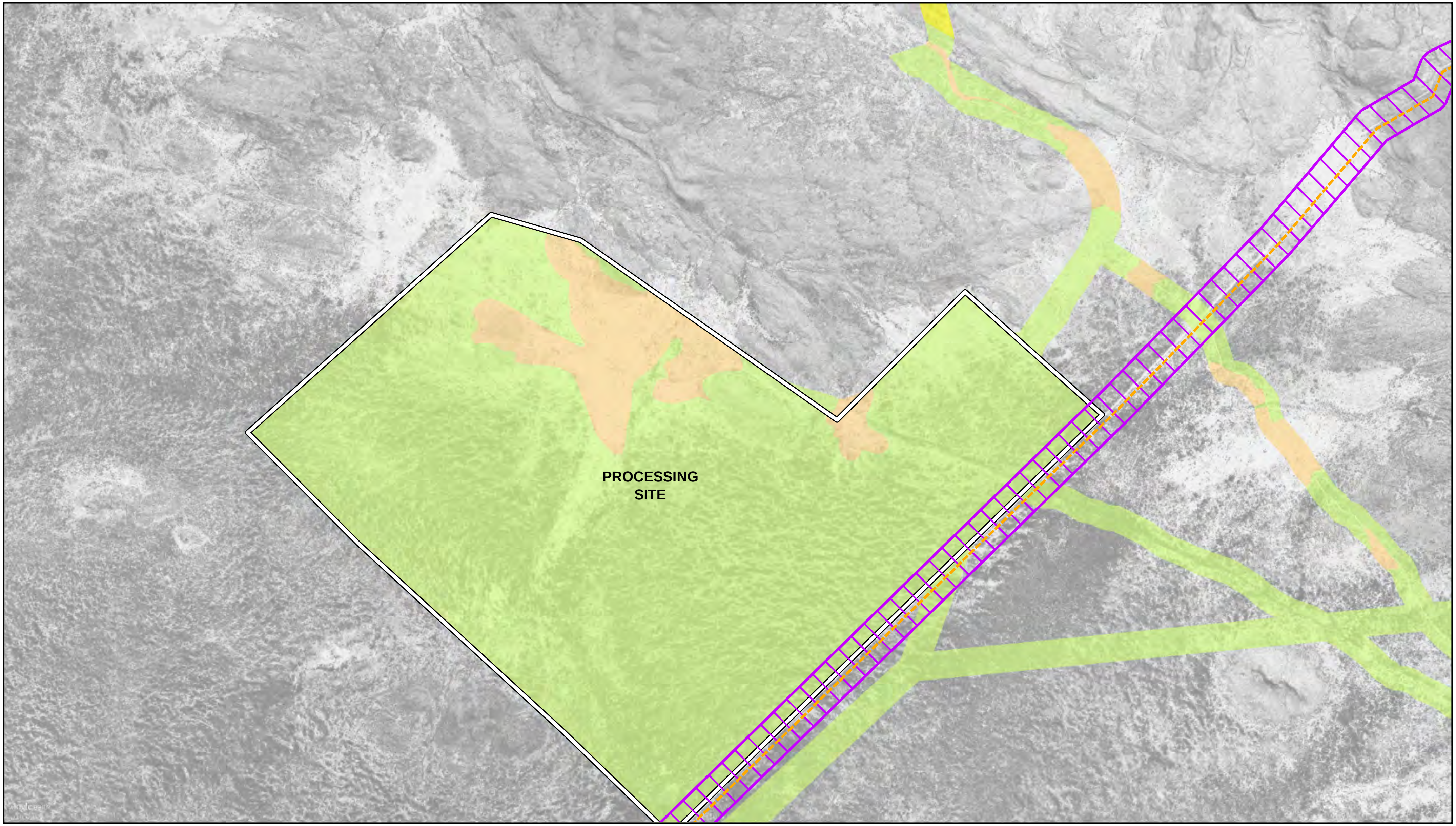
Level 5 66 Smith Street Darwin NT 0800 Australia T 61 8 8982 0100 F 61 8 8981 1075 E drwmail@ghd.com W www.ghd.com

Data source: Google Earth Pro - Imagery (Date extracted: 16/06/2015). GA - Roads (2015). GHD - Vegetation Data, Eragrostis tricophora (2015). Created by: CM



1:40,000 @ A4

0 250 500 750 1,000

Metres

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

N

LEGEND

Eragrostis tricophora

Existing Gas Pipeline

Roads

Indicative Gas Pipeline Corridor

Site Boundaries

Buffel Grass (%)

< 5%

6 - 40%

41 - 70%

71 - 100%

6 5 7 8 4 1 2 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

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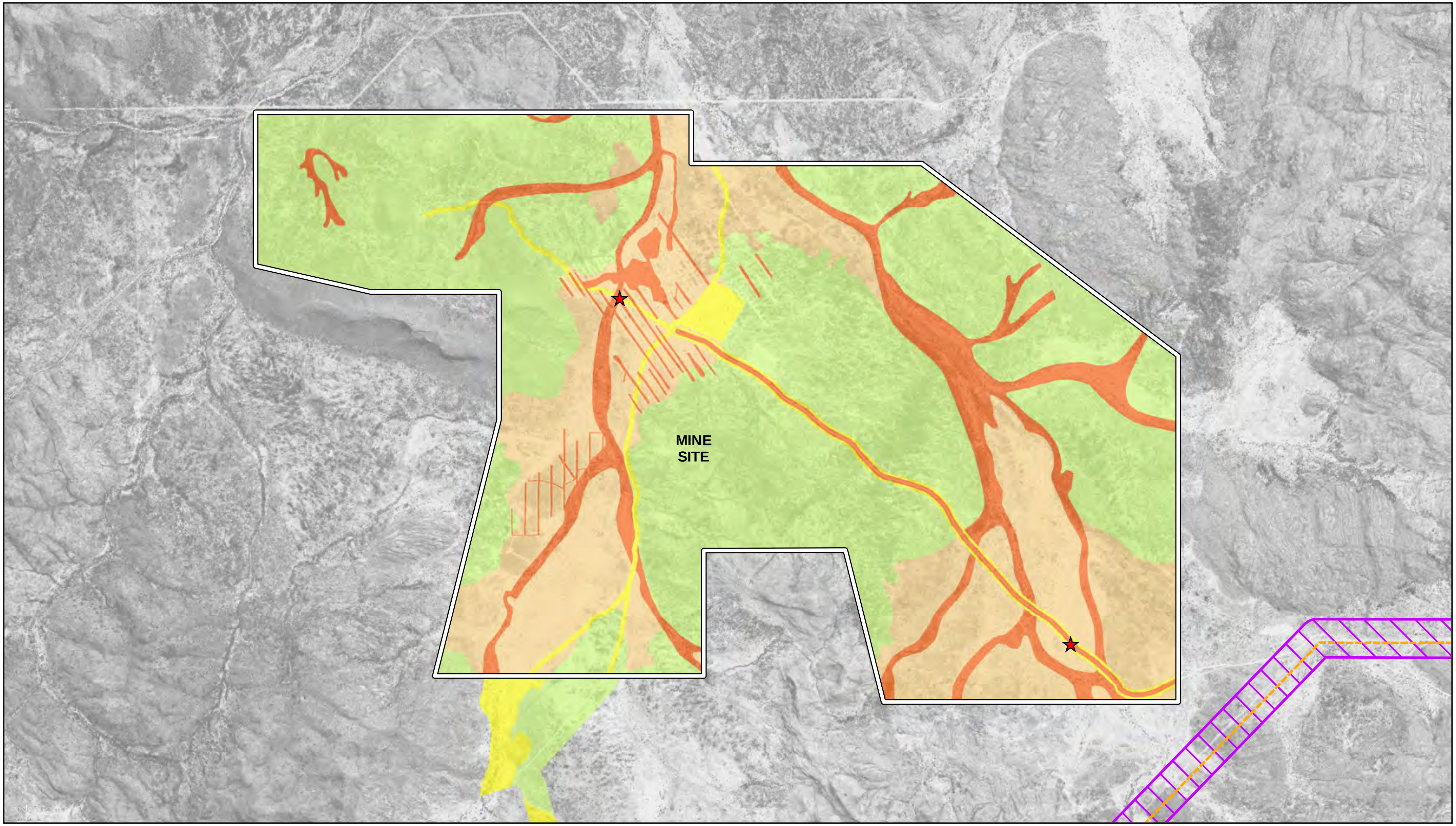

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Metres

Map Projection: Universal Transverse Mercator
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Buffel grass present in the Study area

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Buffel grass present in the Study area

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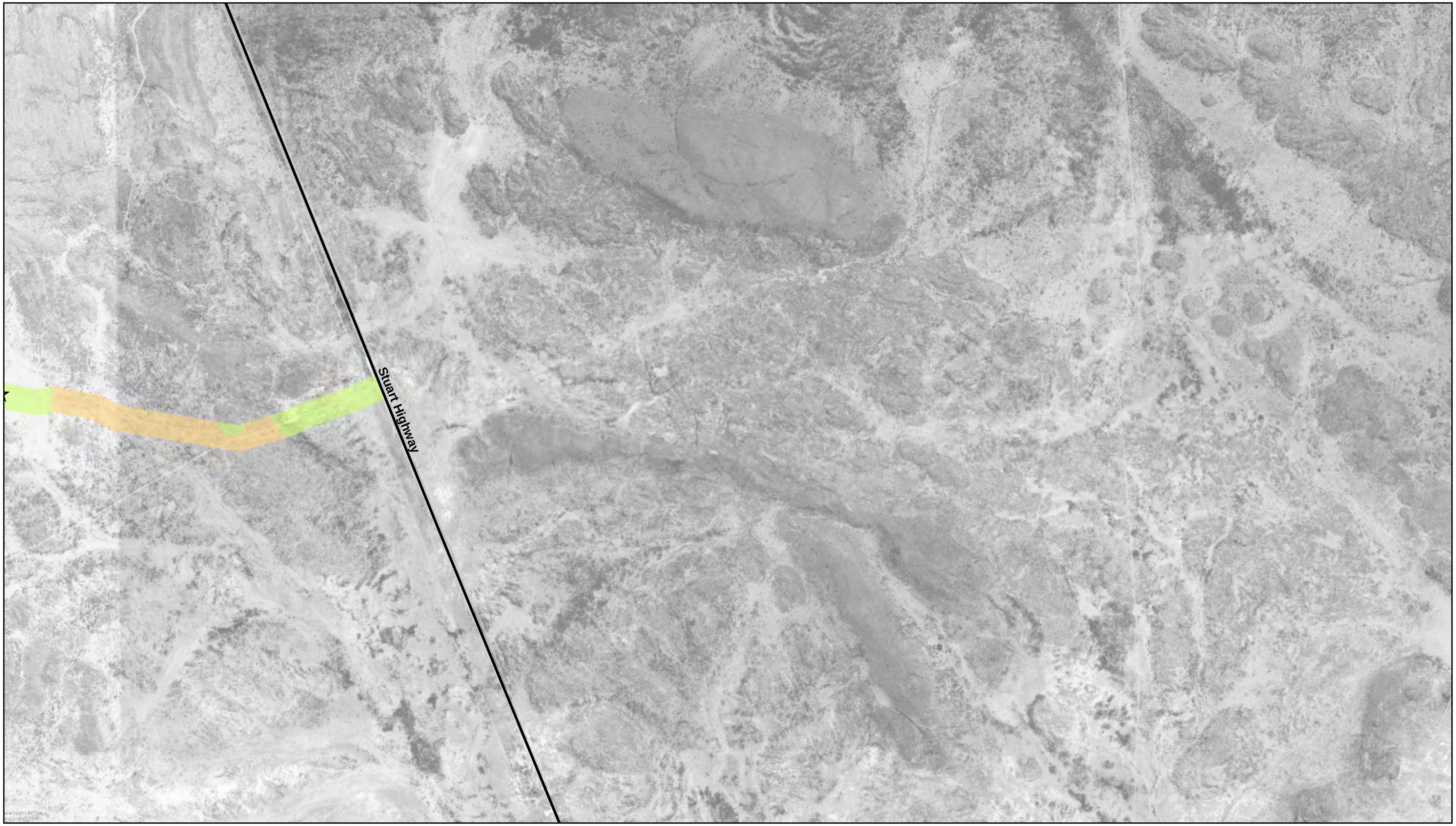
Data source: Google Earth Pro - Imagery (Date extracted: 16/06/2015). GA - Roads (2015). GHD - Vegetation Data, Eragrostis tricophora (2015). Created by: CM



1:40,000 @ A4

0 250 500 750 1,000

Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: GDA 1994
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Data source: Google Earth Pro - Imagery (Date extracted: 16/06/2015). GA - Roads (2015). GHD - Vegetation Data, Eragrostis tricophora (2015). Created by: CM

9.4.3 Flora and communities of conservation significance

No flora species listed under the EPBC Act have been recorded or are predicted to occur within 20 km of the study area. There are three species listed under the EPBC Act that are known to occur within 100 km of the study area (*Macrozamia macdonnellii*, *Olearia macdonnellensis* and *Eleocharis papillosa*) however it is highly unlikely that any of these species would occur within the study area due to the lack of suitable habitat.

There were no communities of national significance known or predicted to occur within 100 km of the study area.

The DLRM herbarium database search identified 412 plant taxa known to occur within 20 km of the study area. Under the TPWC Act, 390 are of ‘least concern’ (i.e. widespread and abundant taxa), eight are ‘not evaluated’, eight are ‘data deficient’ and six are listed as ‘near threatened’ (Holtz 2015).

Nationally and territory significant flora

No flora species listed as threatened under the EPBC or TPWC Acts were recorded within the study area during this or previous surveys of the study area.

The survey identified three flora species listed as near threatened and three species listed as data deficient under the TPWC Act. These species area listed in Table 9-5.

Table 9-5 Near threatened and data deficient species recorded within the study area

Species name	Common name	Status under TPWC Act	Location details
Abutilon lepidum	-	Near threatened	Recorded growing near the base of rocky outcrops within vegetation community 7.
Acacia aneura var. *conifera*	Christmas Tree Mulga	Data deficient	Recorded in low numbers growing on alluvial plains.
Digitaria hystrichoides	Curly Umbrella Grass	Near threatened	Recorded just outside the study area adjacent to a Coolabah Swamp. Within this patch there were approximately 100 individuals of this species.
Euphorbia ferdinandii	Caustic Weed	Data deficient	Sixteen records, mostly in Mulga shrubland and *Triodia* grassland communities along the proposed access tracks.
Eragrostis lanicaulis	-	Data deficient	Recorded at one location within the study area (Quadrat 8), where it was found growing in low abundance within alluvial woodland.

Species name	Common name	Status under TPWC Act	Location details
Vittadinia obovata	-	Near threatened	Three individuals recorded growing on a rocky outcrop near Quadrat 33.

Regionally significant flora

Within the study area 326 species were recorded. This represents 28% of species known to occur within the Burt Plain Bioregion (BRT).

Eleven species listed as having conservation significance in the Burt Plain Bioregion were recorded within the study area. These species have conservation significance due to them being either at the limit of their range or being rare in the bioregion (DLRM 2015). These species and their regional conservation codes are listed in Table 9-6.

Table 9-6 Species with bioregional significance recorded within the study area

Species Name	Common Name	Regional Conservation Code DLRM 2015)
Maireana aphylla	Cottonbush, Leafless Bluebush	BRT (northern range limit)
Maireana scleroptera		BRT (northern range limit)
Convolvulus remotus		BRT (apparently rare)
Swainsona phacoides s.lat.	Dwarf Swainsona, Woodland Swainsona	BRT (northern range limit)
Prostanthera striatiflora	Striped Mint-bush	BRT (northern range limit)
Acacia murrayana	Colony Wattle, Murrays Wattle	BRT (northern range limit)
Aristida arida		BRT (northern range limit)
Aristida hygrometrica	Northern Kerosene Grass, Corkscrew Grass	BRT (apparently rare, disjunct)
Thyridolepis mitchelliana	Window Mulga Grass, Mulga Mitchell Grass, Mulga Grass	BRT (northern range limit)
Oldenlandia mitrasacmoides subsp. *mitrasacmoides*		BRT (southern range limit)
Spartothamnella teucriiflora	Mulga Stick-plant, Scented Stick-plant	BRT (northern range limit)

Nationally and regionally significant vegetation communities

No nationally or regionally significant vegetation communities were recorded within the study area.

Dominant vegetation communities within the study area include mulga communities on red earths, woodlands on alluvial flats and hummock grasslands on sand plains. Most of the vegetation types present within the study area are well represented within the Burt Plain Bioregion, however less than 1% of the Burt Plain Bioregion is conserved within reserves; and thus vegetation communities within the study area are poorly represented in conservation reserves, e.g. hummock grassland 0.01%, Acacia woodland 0.05%, Eucalyptus low woodland with tussock grass understorey 0.01% (NRETAS 2005).

There are also a number of less common vegetation communities that occur in small patches or along linear drainage lines throughout the study area. These include mixed woodlands dominated by bean trees (*Erythrina vespertilio*) and riparian vegetation.

Despite most of the vegetation types within the study area being well represented in the bioregion, Neave et al (2006) recognise that common vegetation types can be regarded as having conservation significance if they meet any of the following criteria:

- Habitat with high species richness that supports a high abundance of native species, and or is structurally complex
- Habitat supporting species of high conservation values (e.g. threatened species, endemic species, poorly reserved species and/or rare species)
- Habitat that is of good quality (i.e. its compositional and structural integrity and ecological processes have not been undermined)
- Habitat that is poorly reserved.

A number of vegetation communities within the study area would meet one or more of these criteria.

These communities include:

- V2 - Mulga shrubland on red earths
- V5 - Hakea/Senna shrubland on calcareous alluvial plains
- V7 - Acacia shrubland with Triodia hummocks on rocky outcrops
- V8 - Rocky or gravelly gneiss or schist outcrops with no spinifex
- V12 - *Triodia basedowii* hummock grassland on sandplains
- V14 - Coolabah swamps associated with claypans (located 80 to 100 m to the south of main access road, approximately 2 km before the accommodation village)

9.5 Results – fauna

9.5.1 Fauna desktop

The desktop assessment revealed records of 185 species within 20 km of the Nolans site (DLRM database, June 2015). These include 17 species of mammal, 121 species of bird, 44 species of reptile and three species of amphibian.

Of the 17 mammals recorded historically in the area (90 records in total), three of them have been recorded only once, and a further four have been recorded only twice. Only eight mammal species have been recorded five times or more. This indicates a relative lack of survey for mammals across the area, except perhaps for insectivorous bats.

Of the 121 bird species recorded historically in the area (1,416 records in total), 44 of them (36.4%) have been recorded ten times or more. This suggests a relatively low level of bird survey effort (or recorded effort) across the region, but it also reflects the sparse and nomadic nature of many bird species across arid habitats, particularly as seasonal conditions change habitats.

Of the 44 reptiles recorded historically in the area (146 records in total), 29 of them (65.9%) have been recorded twice or less, and 22 (50%) have been recorded only once. Only nine reptile species (20.5%) have been recorded five times or more. This indicates that many of the reptile observations are likely to have been from targeted reptile surveys. However, the most-common-reptile list includes none of the larger, more obvious or more iconic species (e.g. Bearded Dragon, Black-headed Python, Thorny Devil), which suggests that many observations of more common fauna have not been included in the DLRM database.

9.5.2 Fauna survey

A total of 124 indigenous terrestrial vertebrate fauna species were recorded during the GHD 2010 baseline fauna survey, including 16 mammals, 78 birds, 27 reptiles, two frogs and one invertebrate. Three introduced fauna species (all mammals) were also recorded.

A total of 130 indigenous terrestrial vertebrate fauna species were recorded during the GHD 2015 baseline fauna survey, including 21 mammals, 78 birds, 28 reptiles, two frogs and one invertebrate. Five introduced fauna species (all mammals) were recorded also.

Table 9-7 summarises fauna identified within the study area during both field surveys in 2010/2011 and 2015.

Table 9-7 Fauna identified within the study area during field surveys

Fauna	Native species	Non-native species	Listed under EPBC Act	Listed under TPWC Act
Mammals	25	5	Black-footed Rock-wallaby, *Petrogale lateralis*	Spectacled Hare-wallaby, *Lagorchestes conspicillatus*; Northern Nailtail Wallaby, *Onychogalea unguifera* Black-footed Rock-wallaby, *Petrogale lateralis* Brush-tailed Mulgara, *Dasycercus blythi*
Birds	103	3	0	Australian Bustard, *Ardeotis australis* Emu, *Dromaius novaehollandiae* Bush Stone-curlew, *Burhinus grallarius* Flock Bronzewing, *Phaps histrionica*
Reptiles	41	0	Great Desert Skink, *Liopholis kintorei*	Great Desert Skink, *Liopholis kintorei*
Frogs	3	0	0	0
Other	Targeted searches for snails and snail shells in apparently suitable habitat failed to detect the threatened species.			

Sampling effectiveness

Compared with the DLRM database results, which are considered to accurately reflect the species that occur within the Nolans site, there is a higher than expected proportion of mammals, and similar proportions of birds and reptiles. The species counts (total, and by group), suggest that the survey methods and effort have effectively sampled the region's fauna, given how closely they match those that have been recorded in the DLRM database (Table 9-8).

The species counts (total and by group) from this assessment, other assessments (i.e. Low 2007, Milligan 1980) and the DLRM database fall short of those recorded for the Burt Plain Bioregion (Table 9-8). This is because the Burt Plain Bioregion covers an enormous area and spans a range of habitats that do not occur within the vicinity of the study area. Thus, the Burt Plain list does not provide the most appropriate benchmark for fauna diversity for this assessment, but it provides useful context in some aspects of fauna diversity, and is referred to where appropriate.

There are varying levels of overlap in species detected for the different groups (i.e., despite similar aggregates, it is not necessarily the same species being detected).

Table 9-8 Overall counts of species (by group) detected during different surveys and in comparison to DLRM records as a gauge of sampling effectiveness

Group	2010 GHD survey	2015 GHD survey	Total (GHD)	Low Ecol 2006	DLRM database	Burt Plain Bioregion
Mammals	19 (3)	26 (5)	30 (5)	18 (3)	17 (5)	63 (9)
Birds	78	78	103	51	121	183 (1)
Reptiles	27	28	41	7	44	104 (1)
Frogs	2	2	3	0	3	9
Invertebrates	1	1	2?	1	0	0
Total	**127 (3)**	**135 (5)**	**179 (5)**	**77 (3)**	**185 (5)**	**359 (11)**

*Non-native species in parentheses, and included in cell totals.

Fauna Diversity and abundance

Detailed information relating to fauna diversity results across the study area is contained in Appendix N, however the results are summarised below. Across both of the surveys undertaken by GHD (2010 and 2015):

- 25 native and five non-native mammal species were identified within the Study area, including Short-beaked Echidna (*Tachyglossus aculeatus*) and Dingo (*Canis lupus*)
- Five species of macropod [Black-footed Rock-wallaby (*Petrogale lateralis*), Euro (*Macropus robustus*), Red Kangaroo (*Macropus rufus*), Northern Nailtail Wallaby (*Onychogalea unguifera*) (scats and tracks) and Spectacled Hare-wallaby (*Lagorchestes conspicillatus*) (tracks)
- Seven species of native small mammal [Brush-tailed Mulgara (*Dasycercus blythi*), Fat-tailed Dunnart (*Sminthopsis crassicaudata*), Stripe-faced Dunnart (*Sminthopsis macroura*), Lesser Hairy-footed Dunnart (*Sminthopsis youngsoni*), Fat-tailed

Pseudantechinus (*Pseudantechinus macdonnellensis*), Sandy Inland Mouse (*Pseudomys hermannsburgensis*) and Spinifex Hopping-mouse (*Notomys alexis*)

- Potentially 11 species of microchiropteran (*insectivorous*) bat [Gould's Wattled Bat (*Chalinolobus gouldii*), Chocolate Wattled Bat (*Chalinolobus morio*), Hairy-nosed Freetail Bat (*Mormopterus eleryi*), Inland Freetail Bat (*Mormopterus petersi*), Lesser Long-eared Bat (*Nyctophilus geoffroyi*), Yellow-bellied Sheathtail Bat (*Saccolaimus flaviventris*), Inland Broad-nosed Bat (*Scotorepens balstoni*), Little Broad-nosed Bat (*Scotorepens greyii*), White-striped Freetail Bat (*Tadarida australis*), Inland Forest Bat (*Vespadelus baverstocki*), and Finlayson's Cave Bat (*Vespadelus finlaysoni*)
- Five species of non-native mammals [Camel (*Camelus dromedarius*), Cat (*Felis catus*), European Rabbit (*Oryctolagus cuniculus*), House Mouse (*Mus musculus*) and Red Fox (*Vulpes vulpes*)]. Cattle (*Bos taurus* and *Bos indicus*) were also seen but not recorded
- 103 native (and zero non-native) bird species were identified. Each survey (i.e., 2010 and 2015) resulted in the detection of 78 bird species, with 68% overlap in species detected. These counts are similar but greater than the numbers of birds detected in previous surveys by Green 2010 (69 species), Low 2007 (50 species) and Milligan 1980 (62 species)
- Fewer than expected waterbirds (8 of 16), reflecting the seasonal or intermittent nature of wetlands and waterbird movements in arid Australia, and the fact that the surveys for this assessment were done at generally dry times of year
- Across surveys undertaken by GHD (2010 and 2015), 41 native (and zero non-native) reptile species were identified within the study area. Each survey (i.e., 2010 and 2015) resulted in the detection of similar reptile species numbers (27 and 28 respectively)
- The reptile sub-group that was obviously underrepresented during the 2010 and 2015 surveys was the elapid snakes. Only one small snake species was detected (Little Spotted Snake, *Suta punctata*), and no large snakes were detected, which is unusual for site visits involving multiple days, multiple teams, working across a large area with extended working hours
- Across surveys undertaken by GHD (2010 and 2015), three native (and zero non-native) frog species were identified within the study area, all of which have been recorded historically in the Burt Plain Bioregion. Nine frog species are known to occur within the Burt Plain Bioregion
- One species of snail was identified during the 2010 and 2015 surveys (and during the survey by Low Ecological 2007): the non-threatened Camaenid land snail (*Sinumelon expositum*).

Fauna habitats

Historical clearing is localised and typically confined to relatively small pastoral infrastructure sites. Fauna habitats are broadly grouped as follows:

- Mulga woodland
- Spinifex grassland on sandplain
- Rocky rises
- Acacia and mallee shrubland/woodland
- Riparian woodland
- Non-spinifex grassland (occasionally with sparse open woodland).

These fauna habitats are described in Appendix N with a brief description of their occurrence within the study area, their habitat attributes, and their relationship to the vegetation communities.

There is variation in habitat characteristics across the study area. In many parts of the study area specific fauna habitats merge or form mosaics with other fauna habitats to some degree (e.g. areas of mulga woodland contain small treeless areas that are dominated by spinifex grassland).

Patterns of species richness and habitat specificity

Table 9-9 summarises patterns of species richness for the different habitat types. This kind of analysis shows fauna species richness across the Nolans site. Habitat specificity results are summarised below and discussed in more detail in Appendix N.

Table 9-9 Counts of fauna species (by group) detected during baseline GHD surveys in the sampled habitats

Habitat Group	Mulga woodland	Sandplain spinifex grassland	Rocky rises	Shrubland/ woodland	Riparian woodland	Open grassland (non-spinifex)	Total
2010 only							
No. sites	4	3	2	1	1	1	12
Mammals	14 (2)	6 (1)	7	3 (1)	2	2	19 (3)
Birds	47	24	46	40	37	20	78
Reptiles	12	9	12	3	2	2	27
Frogs	1	0	0	0	1	0	2
Invertebrates	0	0	1	1	0	0	1
Total	**74 (2)**	**39 (1)**	**66**	**47 (1)**	**42**	**24**	**127 (3)**
2015 only							
No. sites	4	5	2	2	0	0	13
Mammals	18 (2)	16 (4)	8	11	-	-	26 (5)
Birds	47	42	28	41	-	-	78
Reptiles	6	17	9	5	-	-	28
Frogs	0	0	2	0	-	-	2
Invertebrates	0	0	1	0	-	-	1
Total	**71 (2)**	**75 (4)**	**48**	**57**	**-**	**-**	**135 (5)**
Combined (2010 & 2015)							
No. sites	8	8	4	3	1	1	25
Mammals	24 (4)	18 (4)	11	13 (1)	2	2	30 (5)
Birds	64	51	53	63	37	20	103

Habitat Group	Mulga woodland	Sandplain spinifex grassland	Rocky rises	Shrubland/ woodland	Riparian woodland	Open grassland (non-spinifex)	Total
Reptiles	13	20	16	7	2	2	41
Frogs	1	0	2	0	1	0	4
Invertebrates	0	0	2	1	0	0	3
Total	**102 (4)**	**89 (4)**	**84**	**84 (1)**	**42**	**24**	**179 (5)**

*Non-native species in parentheses, and included in cell totals.

Overall, mulga woodland was the most species rich habitat with 102 fauna species detected (including four non-native mammals) during the two survey periods, and was influenced by a high diversity of mammals and birds.

Spinifex-dominated grassland on sandplain was also species-rich fauna habitat with 89 fauna species detected (including four non-native mammals) during the two survey periods. However, the richness detected was inconsistent between surveys. Sandplain spinifex habitat clearly supports a high diversity of fauna, but detecting that fauna is dependent on specific location and environmental conditions. A very high proportion of fauna detected in sandplain spinifex habitat was found only in that habitat.

Rocky habitats were moderately species-rich with 84 fauna species detected during the two survey periods. Reptiles in particular were relatively species rich in rock habitats, particularly in 2010. Larger rocky rises and ranges are more likely to support rocky habitat specialists (e.g. Black-footed Rock-wallaby, *Petrogale lateralis*). A reasonably high proportion of fauna detected in rocky habitat was found only in that habitat. This indicates a relatively high degree of specificity among fauna that use rocky habitats.

Shrubland/woodland was found to be a moderately species-rich fauna habitat with 84 fauna species detected. Birds dominated this habitat (63 species found), however, there was a relatively low diversity of reptiles (three species recorded). Shrubland/woodland habitat is likely to support a higher diversity of fauna than was detected, but detecting that fauna is likely to be dependent on search effort, specific location of sites and environmental conditions encountered.

Riparian woodland was found to support a remarkably high richness of bird species (37 species), but low richness in other vertebrate groups: two species of mammal, two species of reptile, one species of frog. This may be due in part to this habitat's susceptibility to flooding. If a fauna species cannot move from the watercourse during high-flow periods, which in arid areas tend to be intermittent and largely unpredictable, then it is likely to be killed. If it is breeding in that habitat at the time of a flood, then its breeding effort is also likely to fail.

Non-spinifex grassland was found to have a relatively low fauna species richness (24 species in total). More than 80% of species were birds (20 species), with two mammals and two reptiles. All other species detected in grassland were found also in other habitats.

Overall, 71 of the 179 (39.6%) of fauna species were detected in one habitat only. This represents very high overall habitat specificity for fauna in the area.

Introduced species

Twelve introduced fauna species are identified for the study area (Table 9-10).

All of the mammals are known to be capable of invading natural environments, and are generally considered to be responsible for major impacts on Australia's natural environment. Of the ten mammals identified, five have been recorded previously on the DLRM database (i.e., within 20 km of the study area), and six were detected during the baseline survey by GHD in April/May 2015. Cattle are present as an agricultural asset, but all others are present as feral animals.

The introduced fauna that occurs at the Nolans site is likely to have had, and to continue to have, an adverse impact on the area's ecology.

Table 9-10 Introduced (non-native) fauna species identified for the study area

Common name	Scientific name	Burt Plain Bioregion	DLRM database	PMST report	Low Ecol 2006	GHD Baseline survey
Mammals						
Dog	*Canis lupus familiaris*			x		
House Mouse	*Mus musculus*	x	x	x	x	x
Red Fox	*Vulpes vulpes*	x		x		x
Cat	*Felis catus*	x		x	x	x
European Rabbit	*Oryctolagus cuniculus*	x	x			x
Donkey	*Equus asinus*	x				
Horse	*Equus caballus*	x	x			
Camel	*Camelus dromedarius*	x	x	x		x
Cattle	*Bos taurus*	x	x	x	x	x
Goat	*Capra hircus*	x				
Birds						
Rock Dove	*Columba livia*	x		x		
Reptiles						
Asian House Gecko	*Hemidactylus frenatus*	x		x		
Total	***12***	**11**	**5**	**8**	**3**	**6**

BPB – Burt Plain Bioregion; DLRM – Department of Land and Resource Management; PMST – Protected Matters Search Tool; GHD – detected during 2010 or 2015 surveys.

9.6 Potential impacts

9.6.1 Overview

This section will identify the full range of potential direct and indirect impacts on flora and vegetation and fauna presented by the project. These include potential impacts during construction and/or during operations. The construction period is expected to last up to 30 months, and mining and processing operations will continue for a period of 41 years following construction.

The layout of the proposed Nolans site is shown in Chapter 3, and shows the three principal areas comprising the mine site, processing plant and borefield; in addition to accommodation village, utilities corridors and access road.

Construction activities will include all areas of the Nolans site and comprise earthworks, mine site pre stripping and top soil stockpiling, vegetation clearing, construction of infrastructure including waste storage facilities, drainage infrastructure and building pads for modular building structures, construction of roads and access tracks.

Construction activities have the potential to impact on flora and vegetation and fauna:

- Through clearing of vegetation and associated direct loss of breeding or foraging habitat during construction, and potential killing of individual fauna
- Through alteration of hydrological regimes associated with earthworks and associated changes to land surface areas and/or construction of linear infrastructure and/or other impediments to surface flows
- Through erosion and/or sedimentation resulting from vegetation clearing during construction.

Operational activities will include mining, processing and storage of waste rock and tailings/residue materials and water extraction from the borefield. Operational activities have the potential to impact on flora and vegetation and fauna:

- Through the introduction of new exotic flora or fauna species and/or spread of existing exotic flora or fauna species into new areas
- Though changes to fire regimes in local vegetation communities
- Though groundwater drawdown from the borefield and/or changes to groundwater flows impacting groundwater dependent ecosystems
- Through contamination of water resources
- Through dust and/or noise and/or light emissions from the project

These potential impacts are discussed in further detail below.

The maximum disturbance areas for the project are summarised in Table 9-11.

Table 9-11 Maximum area of impact over LOM

Item	Estimated Disturbance Area (ha)
Mine site	2,263
Processing site	1,587
Accommodation village	32
Access roads	125
Access track / utilities corridor	154
Total	**4,161**

The level of risk posed to biodiversity values by each source of impact was assessed using standard qualitative risk assessment procedures, which has been described in Chapter 5 (Risk assessment). The risk associated with each potential impact is detailed in the risk matrix, which is contained in Appendix F.

9.6.2 Impacts on flora and vegetation

Site establishment and clearing of vegetation

Clearing of an estimated 4,161 ha of native vegetation would be required for construction of the mine site pit, waste rock dump, processing site, water supply pipe, tailings storage facility, accommodation village, access roads, mine infrastructure and stockpile sites.

Areas to be cleared for construction will be grubbed of trees and larger vegetation, with material collected and stored for reuse in rehabilitation. Topsoil, where present, will be removed and stored for future use in rehabilitation. Where necessary, stockpiles will be protected with erosion and sediment control structures and stabilised to prevent excessive wind erosion.

The areas of each vegetation community to be impacted by the project are provided in Table 9-12.

Vegetation clearing in these communities will involve removal of a moderately diverse range of non-threatened native plants, including mature trees. The average species richness within vegetation communities present within the Nolans site varies from 51 (+/- 1) within Acacia/ Triodia shrubland on rocky outcrops, to 11 species within Claypans with chenopod and herbs. However, none of the vegetation communities within the Nolans site are considered to have significant levels of species richness or structural complexity.

Vegetation communities present within the Nolans site are well represented in the Burt Plain Bioregion. The two most common vegetation communities in the bioregion, Mulga shrublands on sandy red earths (VT 2) and mixed woodland over tussock grasses (VT 3a) together comprise 78 % of the vegetation proposed to be impacted within the Nolans site.

There are a number of less common vegetation communities in the bioregion that occur in small patches or along linear drainage lines throughout the Nolans site. These include Riparian woodland (VT 1), Cottonbush chenopod shrubland (VT 11), Eucalyptus (Mallee)/Acacia kempeana shrubland with Triodia on rocky slopes (VT 6) and Claypans with chenopods and herbs (VT10). These communities are not considered to be rare or threatened at a regional scale.

None of the vegetation communities to be cleared as a result of the project are listed as threatened under the EPBC or TPWC Act.

Measures to minimise the impacts of vegetation clearing are provided in Section 9.7.2. With the implementation of these measures, the residual risk is expected to be low.

Table 9-12 Vegetation communities impacted by the project

Vegetation code	Vegetation community	Area to be impacted (ha)	% of Nolans site
V*	**Description**		
1	Riparian woodland along water courses and drainage channels	239.96	5.77

Vegetation code	Vegetation community	Area to be impacted (ha)	% of Nolans site
2a	Mulga shrubland on sandy red earths over spinifex	5.90	0.14
2b	Mulga shrubland on sandy red earths over tussock grasses	1411.45	33.92
2c	Mulga shrubland on sandy red earths over chenopods	34.82	0.84
3a	Mixed woodland over tussock grasses	657.18	15.79
3b	Mixed woodland over spinifex	10.97	0.26
3c	Mixed woodland over a highly disturbed understorey dominated by **Cenchrus ciliaris*	6.46	0.16
4	*Triodia schinzii* hummock grassland on red clayey sands	0.00	0.00
5	Hakea/Senna shrubland on calcareous alluvial plains and low rises	232.49	5.59
6	Eucalyptus (mallee)/*Acacia kempeana* shrubland with Triodia on rocky slopes	59.86	1.44
7	Acacia/Triodia shrubland on rocky outcrops	205.99	4.95
8	Rocky gneiss or schist outcrops with no spinifex	0.37	0.01
9	Acacia kempeana and/or Mulga shrubland on gravel	44.44	1.07
10	Claypans with chenopods and herbs	0.12	0.00
11	Cottonbush chenopod shrubland on highly erodible duplex soils	3.55	0.09
12	*Triodia basedowii* hummock grassland on sand plains	105.39	2.53
13	Senna shrubland on quartz	5.96	0.14

Vegetation code	Vegetation community	Area to be impacted (ha)	% of Nolans site
14	Coolabah woodland on claypans	0.00	0.00
2a/2b	Mulga shrubland on sand red earths over tussock grasses / Mulga shrubland on sandy red earths over spinifex	1112.43	26.73
2b/3a	Mulga shrubland on sandy red earths over tussock grasses / Mixed woodland over tussock grasses on alluvial plains	5.23	0.13
3a/12	Mixed woodland over tussock grasses on alluvial plains / Cottenbush chenopod shrubland on highly erodible duplex soils	5.05	0.12
3b/2b	Mixed woodland over spinifex on alluvial plains / Mulga shrubland on sandy red earths over tussock grasses.	13.35	0.32
	Disturbed	0.59	0.01
TOTAL		**4161.56**	**100**

Edge effects

Edge effects can occur where changes in vegetation or landscape can cause changes in vegetation structure or habitat conditions at or near the boundary between areas. Removal of vegetation can result in edge effects such as changes in levels of light and wind etc. Often it is exotic species that will colonise the edges of cleared areas.

The Nolans site is already exposed to the impacts of exotic species such as Buffel Grass, which is present through much of the area. The development of the Nolans Project provides additional opportunities for the creation of edge effects as a result of clearing.

Consequences are likely to include the introduction or spread of weed species and dust to new areas of vegetation, which are currently less affected by these impacts, reducing flora and fauna habitat values in the newly exposed edge areas.

With the implementation of mitigation measures however, including a weed management plan, the residual risk of significant impact associated with edge effects is expected to be low.

Alteration of hydrological regimes

Project activities including earthworks, construction of buildings, changes to land surface areas and other impediments to surface flows associated with infrastructure development and construction of linear infrastructure has the potential to impact on flora and vegetation communities directly or indirectly through alteration of surface and sub-surface flows.

The construction of areas of hardstand and linear infrastructure may interfere with natural surface water flows by blocking or disrupting the movement of water across the landscape. Additionally, the proposed mining operation may impact surface water flows through changes to areas of natural inundation, increased concentration of flows and/or disruption to sheet flow patterns.

Flow pathways including drainage channels, distributed channels and sheet flow areas may be impacted thus directly affecting downstream sensitive vegetation. The key vegetation that is vulnerable to such changes in environmental flow are the vegetation communities that are at least partially dependent on surface water flows including sheet flow i.e. Mulga shrubland (VT 1) and the riparian vegetation along Kerosene Camp Creek and within drainage channels (VT 2).

Approximately 19.2% of the Nolans site is comprised of riparian areas and floodplains that may be subject to seasonal inundation or surface water flows at least occasionally. Haul roads and access roads will need to cross a relatively large number of ephemeral creeks the majority of which have small upstream catchments (typically less than 3 km^2).

A reduction in surface water flows during rainfall periods may result in additional water stress for individual plants and may, in the long term, result in the death of individual species leading to alterations to community composition.

Engineering controls and additional mitigation measures provided in Section 9.7.7 will reduce the residual risk of significant impact to low.

Soil erosion

Erosion and sedimentation due to the stripping of vegetation and construction activities has the potential to impact Kerosene Camp Creek and associated drainage lines through the release of sediments from site during flow events. This may result in impacts to riparian vegetation along the creek and drainage lines.

Concentrated and/or altered hydrology in the construction footprint could further exacerbate the mobilisation and transport of sediment. Potential impacts on flora and vegetation contained in creeks and drainage lines may include increases in stream sediment load, changes in channel form and integrity and/or changes in stream hydrology.

Soil erosion may result in impacts to water quality, instream hydrology and stream habitat integrity. Potential impacts on flora and vegetation contained in creeks and drainage lines may include increases in stream sediment load, changes in channel form and integrity and/or changes in stream hydrology.

Soil protection measures will be implemented during construction and operation of the mine site including the preparation of an Erosion and Sediment Control Plan (ESCP) and progressive rehabilitation of disturbed surfaces (Appendix X, ESCP). The residual risk is expected to be low.

Based on observations and results from rising stream samplers. there is evidence that these systems are already subject to high sediment loads during rainfall events and that the incremental additional load resulting from construction will have little additional impact.

Introduction and/or spread of invasive species

Construction activities have the potential to introduce or increase the spread of weeds via the transportation of seeds on vehicle tyres and machinery, movement or stockpiling of soil and inappropriate waste management. The removal of vegetation would also result in the creation of new exposed edges that are likely to be susceptible to weed invasion (see Section 9.7.4).

Weed species known to be present within the Nolans site are listed in Table 9-4. *Tribulus terrestris* is listed as a declared weed under the *Weeds Management Act 2001* and *Cenchrus* *ciliaris* (Buffel Grass) has been identified as high threat environmental weeds in the Burt Plain Bioregion due to it being a highly invasive species. Buffel Grass has the potential to increase fire severity due to its ability to accumulate higher amounts of combustible biomass compared to native understory species.

Cynodon dactylon (Couch Grass) is also present in low abundance along drainage lines within the Nolans site. This species poses a significant threat to biodiversity in the region due to its ability to rapidly proliferate and spread along drainage systems and out-compete native plant species.

The remainder of the introduced species recorded within the Nolans site are unlikely to have significant impacts on ecosystems as they are present in relatively low numbers and frequency and are not considered to be highly invasive.

Mitigation measures are outlined in Section 9.7.4. A Weed Management Plan (Weed MP) would also be developed for the project (Appendix X). With the implementation of these measures, the residual risk is expected to be medium.

Changes to fire regime

Construction and operational activities, particularly hot works, are potential ignition sources. As are controlled burns that may be necessary to minimise fuel loads around project infrastructure. Without adequate fire management in place, there is potential for these activities to result in uncontrolled bushfires.

Although fire has an influential role in arid zone ecology and is a necessary ecological process in some habitats, too frequent fire can have detrimental impacts on vegetation communities. For instance, fires that are too frequent or too hot have the potential to impact vegetation composition and flora diversity, with some species unable to reach reproductive maturity if time since fire is too short. Additionally, unseasonal fire (i.e. late dry season), or fire in habitats that don’t respond well to fire, can also result in detrimental impacts to vegetation composition and flora diversity.

A fire management plan would be prepared for the Project as detailed in Section 9.7.6 and Appendix X. The residual risk is therefore expected to be low.

Lowering of the water table

The Southern Basins borefield will be established within the alluvial aquifer of the Burt and eastern Whitcherry basins. A number of supply bores with standby bores will provide water for the first four years of the project with additional bores to be installed from year 5 if water supply demand increases. Extraction of approximately 4.5GL to 6GL per annum over the life of the project is predicted to occur.

Additionally, at the mine site, water in the Nolans pit will be pumped during the mining process. This water will be used for the project for dust suppression or in processing.

Groundwater modelling undertaken to predict the likely extent of groundwater drawdown from abstraction (Chapter 8) predicts maximum drawdown is likely to be up to 6 m below current levels within the vicinity of the borefields area and tens of meters immediately surrounding the mine site. At the borefield the modelled groundwater drawdown is very large in terms of its extent., whilst at the mine site drawdown is very large at the pit site, but is likely to have very steep gradient due the low permeability of the rock mass surrounding the orebody. i.e the lateral extent of the drawdown is not significant (Chapter 8)

Groundwater dependent vegetation in discharge zones and floodout areas would be susceptible to rapid changes in groundwater levels, in particular riparian woodlands, which are likely to be at least partially dependant on groundwater. In particular the *Eucalyptus camaldulensis* (River red gum) and *Corymbia aparreninja* (Ghost Gum) growing along creeks and drainage lines may be impacted; particularly if the drawdown occurs quickly, or the level of drawdown is large.

Changes to the water table can result in changes in surface vegetation and habitat characteristics. Lowering of the water table has the potential to result in a decline in availability of water to ecosystems including riparian vegetation resulting in loss of habitat for species relying on riparian habitat.

The extent of the impact to riparian vegetation will be greatest immediately adjacent to the pit and decrease radially with distance from the pit. A reasonable estimate for the down gradient extent of this has been made, based on the both the modelled drawdown cone and the point where Kerosene Camp Creek receives additional surface water flow from adjacent catchments (which is likely to in part mask this impact) at the confluence with Nolans Creek. This is length of Kerosene Camp Creek beyond the mining area, that is unlikely to capable of maintaining the current riparian vegetation, beyond the mining area is less than approximately one kilometre.

At this point the groundwater model predicts a drawdown of two metres during mining but approaches 20 m in the long-term closure model (1,000 years).Impacts are likely to be insignificant as far away as Day Creek, to the west of the borefields, Modelled drawdown from the borefield peaks in the order of 1.5 m over the LOM in the vicinity of Day Creek (Chapter 8) and rebounds rapidly once pumping ceases. It is likely that this level of drawdown over 40 odd years is something to which the riparian vegetation would adapt

further predictive groundwater modelling during operations will allow Arafura to better determine the likelihood of impact on sensitive vegetation and to allow management practices at the borefield to be modified accordingly. With the implementation of measures provided in Section 9.7.7, the residual risk is expected to be medium.

Diversion of Kerosene Camp Creek

Kerosene Camp Creek, which currently traverses the centre of the proposed mine site is a potential source of uncontrolled inflow to the open pit. If unmitigated, the open pit has the potential to capture 30% of the runoff that currently reaches the Woodforde River from Kerosene Camp Creek and Nolans Creek during flow events.

Due to the proposed location of the open pit on the flow path of Kerosene Camp Creek, it will be necessary to divert Kerosene Camp Creek. A western route has been selected to locate the planned diversion away from proposed mining and concentrating activities at the mine site. The diversion will be designed to prevent surface water from the creek entering the open pit during storm rainfall events up to and including a 1 in 1000-year ARI event.

The diversion of Kerosene Camp Creek in the mine site area will result in some landform disturbance and an altered hydrological regime in the old creek bed and in the new creek alignment. This may cause impacts on riparian flora and vegetation downstream of the diversion, including:

- Changes in surface and sub-surface flow downstream of the diversion resulting in impacts on riparian and ephemeral ecosystems and vegetation dependent on overland flows
- Loss or changes in the composition of riparian vegetation associated with the old creek channel due to the reduction in water flow. Some of this vegetation will be within the minesite footprint and would be therefore cleared as a result of mining operations
- Loss of vegetation due to the construction of the new diversion.

With the implementation of mitigation measures provided in Section 9.7.7, the residual risk is expected to be medium.

Contamination of surface and groundwater

There are several risks associated with the construction and operation of the project that could lead to contamination of surface and/or groundwater, and consequent potential impacts on flora and vegetation. These include:

- Contamination of ephemeral creeks/ drainage lines or the groundwater caused by embankment failure or overtopping and subsequent uncontrolled release from waste storage ponds including the residue storage facilities (RSFs) at processing site and/or the tailings storage facility (TSF) at the mine site
- Inappropriate storage and handling of hazardous substances at the mine site and the processing site may also result in uncontrolled release, spills or passive discharge into drainage lines
- Release to groundwater or drainage channels of seepage from waste rock dumps.

Other potential sources of contaminants to surface and groundwater include:

- Contamination via sediment runoff from areas stripped of vegetation or from soil stockpiles during flow events
- Runoff from hardstand areas, including roads, processing areas and site facilities
- Run off from waste treatment areas (including the water treatment plant, wastewater treatment plant, and landfill facilities)
- Leakage or spillage of hydrocarbons from pipelines, vehicles, wash down areas and workshops, refuelling bays and fuel, oil and grease storages.

There are a number of sensitive riparian habitats close to the development footprint, including Kerosene Camp Creek and its associated drainage lines. These areas are sensitive receptors for any adverse impacts on soil and water quality potentially arising from the Project.

Possible embankment overtopping of TSF containing beneficiation tailings during rain events, leading to an uncontrolled release of liquor may result in immediate inundation of flora within the flow path of overtopped embankment. Secondary longer term impacts might include vegetation dieback associated with the contamination of surrounding land and ephemeral creeks.

A number of design controls and mitigation measures have been included to minimise the potential for the release of contaminants into the environment. The site will be designed so that there will be no process or contaminated water stream discharged to the environment. Clean water will be diverted around the site. All reagents will be stored in bunded areas. Hydrocarbons will be store in self bunded tanks or lined and bunded storage areas. Tailings and residue dams will be engineered structures in accordance with relevant standards and will be managed to ensure that the risk of discharge is very low.

An erosion and sediment control plan (ESCP) and a water management plan will be implemented. The implementation of these plans, combined with design measures, is expected to result in a low residual risk.

Dust emissions

Dust is a potential problem for mining projects in regions that experience extended dry periods. Central Australia exhibits an arid and unpredictable climate characterised by extended periods without rain. The mining process, drilling, blasting, excavation, handling of materials and movement of machinery is likely to result in dispersion of particulates and dust.

Dust deposition on leaf surfaces may physically affect individual plants such as by blocking and/or damaging stomata or abrasion of the leaf surface or cuticle which may impact on metabolic processes. Dust can also contribute to cumulative effects such as drought stress on already stressed plants which may in turn lead to the loss of individual plants and longer term changes to vegetation structure and composition.

Whilst the impacts from dust are unlikely to result in the loss of vegetation communities per se, dust has the potential to add an additional stressor to individual plants or plant communities that may be impacted by the effects of weeds or frequent fire, for example.

Impacts on vegetation from dust are likely to be relatively minor and largely restricted to areas adjacent to and downwind of the mine site. A dust management plan will be prepared as part of the EMP for the project (Appendix X). The residual risk is therefore expected to be low.

Radiation

The Nolans Project involves mining and processing of rare earths with which radioactive isotopes are closely associated. Arafura has conducted a radiological risk assessment for flora in the region and found any potential impacts to be negligible. Refer to Chapter 12 for more details.

9.6.3 Impacts on fauna

Potential impacts of radiation on fauna and the level of risk is detailed in Appendix P.

Clearing of breeding and/or foraging habitat

An estimated maximum of 4161 hectares of vegetation over the LOM may be cleared as a result of the project. This equates to around 2.77% of the habitats of this study area.

In all parts of the study area, clearing of areas of habitat, or high impact disturbance to habitat, could potentially result in:

- Killing/injuring fauna
- Displacement of fauna
- Disruption to nesting/roosting/foraging habitats and/or behaviour
- Reduction of area of fauna habitat locally and/or regionally
- Habitat fragmentation
- Erosion and sedimentation resulting from vegetation clearing
- Degradation of surface water quality due to erosion of soils and landforms

- Increasing likelihood of weed establishment in cleared areas.

The diversion of Kerosene Camp Creek and an altered hydrological regime in the old creek bed and in the new creek alignment may cause indirect impacts on fauna through the loss of habitats as a result of changes in surface and sub-surface flow.

Construction of linear infrastructure (e.g. access roads and water supply pipelines) through natural habitat may result in:

- Habitat fragmentation, particularly for small ground-dwelling fauna
- Introduction and/or spread of exotic plants (weeds)
- Increase in the area of habitat used by non-native predators, by creation of tracks.

The areas to be cleared will form small islands of cleared habitat in a near continuous landscape of native vegetation. The clearing area is bounded to the south by the Reaphook Hills and Hann Range, and the Stuart Highway to the east. The proposed project as planned will not cause any fragmentation of habitat.

Specific impacts on habitat of EPBC listed threatened species within the study area are described in Chapter 10. The fauna as a whole is similarly likely to experience no significant effects from the clearing and infrastructure development itself, with other impacts discussed below such as vehicle strike and the introduction of exotic predators likely to be more important for future management.

The risk of impacts from clearing would likely not be amenable to detection at the population level, and thus has been rated as low.

Specific mitigation measures may need to be implemented for species with very small known populations such as the Great Desert Skink in the south-west of the study area (See Chapter 10). The active warren is not currently part of the proposed development and this would need to remain through protection of this location.

Dust generated by mining and processing activities

Dust is a potential problem for projects in regions that experience extended dry periods. Central Australia exhibits an arid and unpredictable climate that can extend for periods of months without rain. Potential impacts of dust/emissions on fauna can include:

- Degradation/loss of fauna habitat from detrimental impacts of dust deposition on flora species and vegetation communities
- Degradation/loss of water source for fauna resulting from degradation of surface water quality due to dust deposition/sedimentation.

The following activities are identified as potentially the main generators of dust:

- Uncontrolled dispersion of particulates and dust from the concentrator (comminution and beneficiation circuits) at the mine site, resulting in dispersion of particulate, gas or dust
- Operation of RE processing units, sulfuric acid plant and gas fired generators at the processing site results in dispersion of particulate, gas or dust
- Haulage and transport of material within the mine site, along haul roads and tracks resulting in dispersion of particulate, gas or dust
- General site movements over unsealed surfaces resulting in dispersion of particulate, gas or dust

- Wind erosion mobilising dust from exposed surfaces, such as pits, WRDs, tailings and residue storage facilities, laydown areas, stockpiles, roads and sites of vegetation clearing.
- Drilling, blasting, excavation, movement of vehicles and handling of materials results in dispersion of particulates and dust, particularly from the mine site, and consequent soil, surface/groundwater contamination.

It is likely that a range of fauna that exist within the vicinity of the proposed mine site could be adversely impacted by dust generated by mine operations. This would include birds, small ground-dwelling mammals and possibly small reptiles. Populations of Black-footed Rock-wallaby which occur within 2 km of the mine site could be subjected to low levels of dust (Chapter 10).

Mitigation measures as discussed in Section 9.7.8 would be implemented to keep dust levels to a minimum. The residual risk of impact associated with dust is low.

Noise and vibration generated by mining and processing activities

Disturbance to fauna associated with generation of unexpected and/or excessive noise from mining and processing activities during construction can result in the displacement of fauna and disruption to nesting/roosting/foraging behaviour. Displacement of fauna into sub-optimal habitats could increase their susceptibility to predation and competition.

It is likely that faunal communities in the immediate vicinity of the mine site would be most acutely affected by the mining operations, including drilling, blasting and excavations that may result in audible airborne and ground borne noise and/or vibration.

. It is quite likely that noise generated by the mine could preclude fauna movements through the mine site as has occurred previously, however particularly noisy activities would likely occur during diurnal periods when fauna e.g. rock-wallabies are sheltering, and noise would be somewhat buffered by their rocky, elevated habitat.

Increased vehicle noise in the borefield could have some localised and isolated low-level impacts however most of these species are nocturnal and their activity patterns would unlikely be adversely impacted by activity in the borefield at night. Vehicle passage in this area would be infrequent for maintenance purposes and may only occur on a weekly basis.

With mitigation measures in place the risk of impact associated with noise and vibration has been assessed as being low.

Artificial light generated by mining and processing activities

Light plays a critical role in ecology. It determines activity levels of diurnal and nocturnal fauna, it assists predators in their hunting success, and some light sources attract invertebrate fauna that attract and are then preyed on by other fauna. Localised disturbance to nocturnal fauna associated with generation of light in mining and processing areas can cause the following impacts on fauna:

- Local displacement of fauna (i.e., nocturnal fauna moves away from brightly lit areas)
- Increased susceptibility of fauna to predation (e.g., prey species find it harder to remain concealed in brightly lit areas)
- Disruption to nesting/roosting behaviour (e.g., bright lights may awaken diurnal species).
- Disorientation of migrating birds (e.g. Longcore et al. 2008)
- Attraction and disorientation of amphibians (Buchanan 2006)
- Disorientation of bats (e.g. Stone et al., 2009; Polak 12011)

- Attraction of and enhanced mortality of insects (e.g. Yoon et al., 2010; Ferreira and Scheffrahn 2011; Fox 2012)
- Alteration of bird calling behaviour (e.g. Kepempenaers et al., 2010; Loncore 2010)
- Breeding behaviour of amphibians (e.g. Baker and Richardson 2005)
- Small mammal activity rhythms (e.g. Rotics et al., 2011).

It is likely that faunal communities in the immediate vicinity of the mine site and mine operations would be most acutely affected by the project and could experience periods of prolonged lighting that could impact on 'normal' nocturnal behaviours. The residual risk of artificial light impacting fauna has been assessed as being low.

Unplanned wildfire

The Nolans Project introduces a range of potential sources of fire. Vehicles, machinery, hot works, switchgear, transformers, HV power and personnel provide potential ignition sources that could lead to fire.

In addition to the potential for wildfire to result in death or injury to fauna, indirect impacts such as fauna displacement and impacts on nesting/roosting or foraging habitats may also occur. The loss of vegetation could lead to subsequent erosion and impacts on water sources utilised by fauna.

The impacts of too frequent, hot and extensive fires are well documented in the arid zone of central Australia (Woinarski *et al.* 2007) which would be consistent with the project area. A number of the threatened species recorded within the study area are adversely affected by too frequent and extensive fires. Large-scale, intense wildfires from a lack of patch burning can devastate or fragment local populations of Great Desert Skink (Woinarski *et. al.* 2007). Wildfire within Black-footed Rock-wallaby habitat is also a major impact on populations as it burns food plants such as Spearbush and fig rendering habitats unsuitable for periods of time (Dr J. Read *pers. comm.*).

There is great potential for the proposal to lead to increased wildfire in the study area in the event that appropriate mitigation measures are not implemented. It is expected that all of the threatened species either known or potentially occurring within the study area would be affected by fire (both positive and negative impacts).

Controlled and strategic cool patch burns of spinifex sandplain habitat could have positive outcomes for species such as Greater Bilby (promotes food plants). Extensive burns (not patchy) of Great Desert Skink and Black-footed Rock-wallaby habitat could be detrimental as the fire would remove important shelter and food resources.

There is limited information regarding the response to fire for the Brush-tailed Mulgara. Woinarski 2007 does mention that changes fire regimes may have been a factor in the historic decline of mulgaras. Removal of ground layer vegetation is thought to leave mulgaras more vulnerable to predation (Kortner et al. 2007).

For other species, too, extensive frequent fire may reduce ground-layer vegetation cover which could increase the chance of predation by cats/foxes (Dr R. Paltridge *pers. comm.*).

Too frequent, hot and extensive wildfire is unlikely to benefit fauna in the study area and surrounds, whereas localised cool patch burns are likely to be beneficial. The residual risk of wildfire impacting fauna has been assessed as being medium. A fire management plan is included (Appendix X).

Introduction and/or spread of exotic plants and animals

Transport of materials, vehicle movements and inappropriate waste management allows for introduction of new weeds and spread of existing weeds during construction and operations. These can cause:

- Local decline in habitat quality
- Displacement of fauna from habitats as habitat quality deteriorates
- Invasion of fauna species that are attracted to the weed species (e.g. cattle with Buffel Grass)
- Impacts on conservation significant fauna (i.e., threatened species)
- Changes in fuel load, resulting in changes to fire frequency and intensity.

Creation of new roads and tracks and inappropriate management of waste (garbage) allows for introduction or spread of pest animal species. This can cause:

- Increased predation pressure (particularly on threatened species) by opening up of new areas to feral predators such as cats or red foxes
- Increased competition (particularly on threatened species) by natural areas becoming invaded by aggressive and dominating native and pest species
- Large-scale decline in habitat quality as natural areas are trampled and grazed increasingly by non-native species that have the potential to alter ecological processes.

Feral (and native) predators appear to be common within the study area, with several recordings of foxes, cats and dingoes during the field assessment within the bore site. Each of these species was also recorded on the mine site.

It will be important that with an increase in people on site, that putrescent waste is contained and managed within a predator-proof fence to prevent access (access to easily obtain food resources could allow predators to increase in abundance).

On the assumption that appropriate mitigation measures are implemented the residual risk associated with the introduction of weeds and feral animals has been assessed as medium.

Radioactivity

Arafura has conducted a radiological risk assessment for fauna in the region and found potential impacts from the proejct to be negligible. Refer to Chapter 12 (Radiation) for more detail.

Poisoning of fauna from drinking contaminated water

Wildlife ingestion or exposure to supernatant material at mine site or processing site is documented in the Australian literature (Ryan and Shanks 1996).

Effects can be immediate or cumulative. Consumption of contaminated water by fauna can cause:

- Death or harm
- Disruption to breeding success
- Knock-on effects, by attracting predators/scavengers to ill/dead fauna.

The Nolans Project TSF/RSFs will be small (approx. 244.03 ha) and will likely contain free-standing supernatant water.

There would be an extremely low chance that passing Princess Parrots or other threatened species would stop for a drink at a TSF/RSF. There is a low potential for other non-threatened fauna to access the water at these facilities.

Lowering or contamination of the water table

Changes to the water table can lead to changes in surface vegetation and habitat characteristics, particularly those communities reliant on surface water runoff and groundwater (e.g. riparian vegetation). Lowering or contamination of the water table has the potential to cause the following indirect impacts on fauna:

- Impacts on vegetation that rely on groundwater or surface water flows, in turn leading to reduction in available habitat
- Contamination of ephemeral waterways and subsequently groundwater in the broader area from uncontrolled release resulting in impacts on ecosystem health and/or public water supply
- Unnatural inundation of fauna habitats.

In this project, the water table (and therefore fauna habitat) could be impacted in the following areas and in the following ways:

- Progressive water table drawdown should an unsustainable groundwater extraction rate be applied tothe Southern Basins borefield
- Mine void results in a long-term source of contaminated (saline) water with the potential to contaminate groundwater
- Embankment failure or overtopping of TSF at mine site and RSFs at the processing site, due to slope instability or an extreme wet weather event (all of which could damage fauna habitat)
- Inappropriate storage and handling of hazardous substances on the mine site or processing site resulting in uncontrolled release, spills or passive discharge.

Lowering of the water table due to groundwater drawdown could occur within the mine site, processing facility and borefield, however only the mine site appears to support Groundwater Dependent Ecosystems (GDEs) such as riparian River Red Gum communities. The above-listed potential impacts will be carefully monitored, managed and controlled during mine operations, rehabilitation and closure phases.

Fauna are unlikely to be directly impacted by water table impacts. However, residual and ‘knock on’ impacts could occur but there is a low risk that any of these species could consume contaminated water.

Injury and death from collisions with vehicles

Creation and use of new roads and tracks through fauna habitats can lead to increased likelihood of collisions with fauna, particularly at night, when nocturnal fauna can become dazed by a vehicle’s bright lights.

There is potential for several of the species that occur within the borefield site to be occasionally struck and killed by vehicles moving in the area. However, the majority of the threatened species that are known or have the potential to occur in the study area are nocturnal, and would only be affected by vehicles travelling at night. Most mining activity is schedule to occur in daylight hours and only the concentrator at the mine site will operate 24 hours a day. This will substantially reduce vehicle movements between the mine site and processing site and therefore reduce the risk of this occurring. Mitigation discussed in Section 9.7.12 would likely involve the implementation of speed limits and possibly the reduction in vehicle travel at night.

9.7 Mitigation measures

Mitigation measures will be required to control, reduce or eliminate impacts of project activities on flora and fauna and their habitat. Monitoring may be required for some aspects, to evaluate level of impact and effectiveness of mitigation.

This section provides guidance on the types of mitigation and monitoring that will be considered for the construction and operations phases of the project. All mitigation and monitoring efforts will be described in detail in a Biodiversity Management Plan (Appendix X), prior to impact activities taking place.

9.7.1 Avoidance of impacts

Detailed Project design will consider options for aligning infrastructure footprints to avoid or minimise clearing of vegetation. In particular, the Project will aim to avoid where possible, sensitive vegetation types such as riparian vegetation and or sites where listed threatened species are known to occur.

The design will also seek to minimise modifications to surface water flows that would cause vegetation stress, or the proliferation of introduced flora species.

Selection of appropriate ANCOLD risk category and adherence to relevant design standards for the provision of adequate storage capacity, spillway capacity and freeboard allowance will minimise risk of storage facility failure or overtopping.

Engineering controls that maintain existing surface water flows will be incorporated into road and infrastructure designs. Given the relatively small variation in relief across the Nolans site, these practices will also provide other benefits such as erosion control whilst maintaining natural surface water flows.

Design features that recognise the need to maintain existing surface water flows include the installation of at-grade flood ways where the access road crosses a water course, and culverts to maintain flows under the access road where the drainage line is well defined (i.e. along Kerosene Camp and Rabbit creeks).

The diversion of stream flow from areas upstream of the processing plant by means of flood protection bunds and/or shallow drainage ditches will be implemented. The design of these structures will adhere to relevant design standards and it is assumed that the height of pond embankments will be sufficient to prevent ingress from external flood runoff during an event that is compatible with the design of its water containment capacity.

9.7.2 Mitigation of Impacts associated with land clearing

The amount of land disturbance and vegetation clearing will be minimised. Construction personnel would be briefed during inductions regarding the conservation value of surrounding habitats and their responsibilities with regard to protecting these habitats during construction.

Additional control measures will include:

- Procedures for demarcating the limits of clearing and no-go areas
- Staged clearing of vegetation to minimise areas of bare ground and clear land only as required and in accordance with ESCP
- Construction and clearing would be limited to during non-breeding periods where reasonable and feasible

- Consideration of a cool, well managed fuel reduction burns of all habitats to be cleared to allow fauna to have the chance to escape prior to clearing of vegetation, or pre-clearing fauna surveys would be conducted prior to construction of the mine with qualified ecologists on site to capture and translocate animals that are found during the clearing process
- Strict fire prevention management protocols to prevent wildfire during clearing activities
- Use of already-disturbed areas (rather than undisturbed areas) wherever possible (e.g. lay down areas for construction)
- Development and implementation of a land stabilisation and revegetation strategy
- Progressive revegetation of cleared land as activities are completed

9.7.3 Mitigation of impacts associated with soil erosion

A draft ESCP has been developed as a sub plan to the EMP (Appendix X) including:

- Installation of erosion and sediment control measures prior to construction
- Regular inspection of erosion and sediment control measures, particularly following rainfall events, to ensure their ongoing functionality
- Runoff from disturbed and rehabilitated areas diverted into sediment ponds and not discharged into the natural system before monitoring
- Constructing adequate bunds around potential contamination sources, to contain contaminated water in the event of heavy rainfall
- Runoff from ROM pad, stockpiles and workshops would be directed to sediment basins
- Siting of stockpiles away from natural drainage channels
- Staged clearing of vegetation to minimise areas of bare ground and clear land only as required and in accordance with ESCP
- Avoid land clearing for construction during the wet season
- Minimise surface water infiltration, water runoff and groundwater seepage
- Preparation of a Water Management Plan for construction activities
- Spill clean-up and emergency management procedures developed and implemented
- Personnel to be trained in the use of spill kits and emergency response procedures.

9.7.4 Mitigation of impacts associated with weeds

A Weed MP will be prepared and include the following:

- Information regarding type and location of weeds of concern within the Nolans site
- Description of sensitive receivers (such as native vegetation and waterways)
- Measures to prevent the spread of weeds, including hygiene procedures for equipment, footwear and clothing
- Mitigation measures to minimise the spread of weeds such as ensuring that any machinery entering the Nolans site is free of weed seed. This would typically be managed through inspections and the use of vehicle wash down stations
- Keeping vehicles to established tracks and roads, and limiting the use of vehicles off-road

- Areas supporting existing weed infestations, or vulnerable to weed infestation, will be avoided where practicable
- Protocols for weed removal prior to vegetation clearing so that vegetative material would be clean and able to be mulched and reused directly on site.
- Weed disposal protocols
- Ongoing control of new weed outbreaks
- Annual monitoring of the Nolans site (including rehabilitated areas) and surrounding vegetation to identify new weed populations and monitor the effectiveness of weed control measures
- Topsoil from weed affected areas will be stockpiled in a designated area with appropriate signage and bunding. Weed infested topsoil will be treated as required to eradicate weeds prior to re-spreading in rehabilitation areas
- All staff and contractors will be informed of weed hygiene measures and weed reporting requirements during the site induction

9.7.5 Mitigation of impacts associated with predatory and feral animals

- Waste management to limit invasion/colonisation by dingoes and Black Rat (*Rattus rattus*). This will also be particularly important for the Black-footed Rock-wallaby population near the mine site as any on-site garbage waste will need to be held in a securely fenced compound to prevent the scavenging of waste material and potential population increases in both feral and native predators
- Investigate innovative new passive baiting and trapping methods such as the newly developed ‘Feral Cat Grooming Trap
- Undertaking monitoring of feral fauna species, including dingos, to determine if a pest eradication program is required. This will be managed through the Pest Monitoring and Control Plan in the Biodiversity management plan (BMP).

9.7.6 Mitigation of impacts associated with fire

Development and implementation of a Fire Management Plan (FMP) including:

- Establishment and maintenance of fire breaks around high-risk areas / activities
- All welding, cutting and grinding works undertaken will require approval via an internal hot works permit system
- Active fire management and vegetation reduction program where necessary;
- Installation / implementation of fire detection and suppression systems including dedicated fire extinguishers,
- All site personnel will be required to undertake fire control training, including the correct use of extinguishers
- All mobile equipment to be fitted with fire suppression systems
- All vehicles are required to carry a fire extinguisher and two-way radio
- Emergency response procedures, team and equipment
- Establishment of dedicated fire water system on site.
- Strict fire prevention management protocols to prevent wildfire during clearing activities

- Erosion control in waterways, if fire should occur and results in loss of vegetation that otherwise stabilises soil/sediments
- Undertake active fire management and the use of cool-season control burns if needed

9.7.7 Mitigation of impacts associated with water flows

Development and implementation of a Water Management Plan (WMP) including:

- Undertake predictive groundwater flow modelling to confirm the extent of groundwater drawdown
- Establish ground water monitoring bores to assess impacts over time on water table
- Visual monitoring of vegetation potentially at risk of impact from a lowering of the water table
- If significant impacts are identified, consider mitigation options. This could include modification of the pumping regime to manage groundwater levels.

9.7.8 Mitigation of impacts associated with dust

Development and implementation of a Dust Management Plan (DMP) would include as a minimum, application of industry dust control measures including:

- Use of water sprays on haul roads, unsealed surfaces, covering of exposed loads where practicable and maintaining moisture levels in bulk loose construction materials
- Minimising hauling and vehicle travel in conditions when wind strength results in spatially extensive and heavy dust deposition in surrounding habitats
- Reduced vehicle speeds for high-use areas/roads
- Minimise open areas exposed to wind erosion
- Wetting of ore before crushing and design controls such as use of hooded crusher, covered conveyor and an enclosed high pressure roller grinding (HPRG)
- Topsoil striping to occur only during suitable wind and weather conditions
- Review of wind directions and wind speeds prior to drilling, blasting or excavation of materials
- Minimise time between top soil stripping and construction/mining operations
- Progressive reinstatement of WRDs and cleared land as construction works are completed
- Controlled emissions release via stack and scrubber- Ongoing dust deposition monitoring program.

9.7.9 Mitigation of impacts associated with noise

- Minimising noise wherever possible
- Limiting high-impact noise, such as blasting, to daylight hours only to reduce the impact on nocturnal fauna

9.7.10 Mitigation of impacts associated with artificial light

- Limiting artificial light to areas where it is essential
- Turning off lights when not required

- Limiting the escape of light into surrounding areas of fauna habitat (i.e. using shields/deflectors)
- Ensuring that artificial lighting is not directed upwards or laterally (i.e. should be directed towards the ground)
- Use of lower rather than higher lighting installations
- Use of lower wavelengths of light wherever possible, i.e. red/yellow lights
- Use of light intensities that are as low as possible without reducing safety or efficiency
- Avoiding painting large structures bright or reflective colours and minimise use of bright or reflective construction materials and finishes for large structures.

9.7.11 Mitigation of impacts associated with tailings dam water ingestion

- The reduction of impacts of TSF/RSFs on wildlife by following best practice guidelines currently recommended for the Northern Territory where practicable
- The reduction of the attractiveness of the dam landscape for wildlife via design that includes, but is not limited to, the reduction of the dam surface area, removing dam bank vegetation, creating steep dam walls, providing alternative adjacent 'fauna friendly' water sources, and avoiding the creation of islands in the dam
- Fencing off the TSF and RSFs to prevent ground-based fauna from accessing the water
- Looking into, where possible, implementing appropriate bird-deterrent methods to keep waterbirds and birds of prey away.

9.7.12 Mitigation of impacts associated with fauna injury and death from collisions with vehicles

To minimise and mitigate the effects of increased road traffic or increased road network on the threatened species populations the following actions are recommended;

- Keep the proposed road network to a minimum and upgrade and utilise existing vehicle tracks
- Reduce speed limits and install speed reduction infrastructure such as whoa-boys and speed humps
- Provide road safety and awareness training to all staff and contractors with respect to safe driving in areas where native wildlife occurs
- Implementing and enforcing speed restrictions in high-use areas
- Limiting the movement of vehicles at night (between the period of one hour before dusk to one hour after dawn)
- Monitoring roadkill for threatened species
- Documenting location and time of day of roadkill within the study area, to determine high-risk periods or locations (additional mitigation may be required)
- Fatigue management for vehicle operators
- Development and implementation of a Traffic Management Plan.

9.7.13 Rehabilitation strategies

- Areas not required for ongoing operations will be progressively rehabilitated

- Locate and design landforms to be rehabilitated to optimise blending with the surrounding topography
- Topsoil will be stripped and stockpiled in a designated area, to prevent erosion or run-off
- Minimise soil erosion particularly on the batters of the WRD
- Stockpile vegetative material and topsoil for later use
- Minimise length of stockpiling of vegetation and topsoil
- Seeds collected for the rehabilitation program will be sourced locally, within a 20 km radius of the Nolans site, wherever possible.
- Annual monitoring of rehabilitation areas would be undertaken prior to, and following completion of rehabilitation
- If monitoring identifies that completion criteria are not being met, additional rehabilitation and monitoring would be completed until such criteria are met.

Rehabilitated areas will be monitored to ensure the success of the rehabilitation programme and impacts from mining activities. Monitoring of rehabilitated sites would be undertaken annually until completion criteria have been met. The monitoring would assess the species diversity, plant density and community structure against agreed completion criteria, which include:

- Species richness, species diversity and plant density of the restored community exceeds the median in the range of values established for baseline vegetation communities
- Dominant species in the restored community are also dominant in the baseline vegetation communities.

10

Protected Matters under the EPBC Act

10. Protected Matters under the EPBC Act

10.1 Introduction

This chapter addresses matters specific to the *Environment Protection and Biodiversity Conservation Act 1999* (Cth) (EPBC Act), and in particular, potential impacts on Matters of National Environmental Significance (MNES).

Section 1.1 of the TOR for the preparation of an environmental impact assessment issued by the NT EPA for the Nolans Project has identified that the project '… *has the potential to have a significant impact on the following matters of national environmental significance that are protected under Part 3 of the EPBC Act:*

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

This chapter provides an assessment of the threatened fauna species and/or populations listed under the EPBC Act that are present or considered likely to occur within the study area including:

- The quality and quantity of available habitat within the vicinity of the study area (identified and mapped)
- The regional and national significance of populations of threatened species
- The potential impact of the project on these species and their populations
- Proposing mitigation measures to reduce the risk of impacts that may be significant
- the residual risks to threatened species.

No listed, threatened flora species or threated ecological communities are known and/or likely to occur in the vicinity of the Nolans site, therefore the focus in this Chapter is listed, threatened fauna species.

A detailed fauna assessment, including listed threatened species is available in Appendix N.

10.2 Environment Protection and Biodiversity Conservation Act (1999)

The EPBC Act focuses Australian Government interests on the protection of matters of national environmental significance, with the states and territories having responsibility for matters of state and local significance. The Act has been discussed in detail in Chapter 2 of this EIS

The delegate of the Commonwealth Minister has determined that the project is a controlled action that has the potential to significantly impact listed, threatened species and communities (under Sections 18 and 18A of the EPBC Act).

On 16 March 2015, the delegate of the Minister determined, based on an EPBC referral submitted by the Proponent, that the proposed action (the project) is a controlled action that has the potential to significantly impact on the on the following MNES:

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

The proposed action will be assessed under the Bilateral Agreement between the NT and Commonwealth governments. The construction corridor for the project may coincide with habitat of EPBC-listed threatened species. This chapter addresses the EPBC-listed threatened species and communities.

10.3 Definitions

Listed threatened species and communities protected under the EPBC Act include species and communities that are considered to be either:

- extinct
- extinct in the wild
- critically endangered
- endangered
- vulnerable
- conservation dependent.

To determine if an action will have a significant impact, criteria have been developed for each of the abovementioned categories. The significant impact criteria are listed in the *Significant Impact Guidelines 1.1 - Matters of National Environmental Significance*, developed by the former Department of Environment (2013), and include:

- Lead to a long-term decrease in the size of a population
- Reduce the area of occupancy of the species
- Fragment an existing population into two or more populations
- Adversely affect habitat critical to the survival of a species
- Disrupt the breeding cycle of a population
- Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline
- Result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat
- Introduce disease that may cause the species to decline or
- Interfere with the recovery of the species.

Definitions for threatened species impacts

Assessment under the Significant Impact Guidelines 1.1 includes the use of three definitions in its description of impact criteria, namely, population, important population and habitat critical to the survival of a species or ecological community:

- A *population* of a species' is defined under the EPBC Act as an occurrence of the species in a particular area. In relation to critically endangered, endangered or vulnerable threatened species, occurrences include but are not limited to:
  - A geographically distinct regional population, or collection of local populations or
  - A population, or collection of local populations, that occurs within a particular bioregion.
- An *important population* is a population that is necessary for a species' long-term survival and recovery. This may include populations identified as such in recovery plans, and/or that are:
  - Key source populations either for breeding or dispersal
  - Populations that are necessary for maintaining genetic diversity, and/or
  - Populations that are near the limit of the species range.

- *Habitat critical to the survival of a species or ecological community* refers to areas that are necessary:
  - For activities such as foraging, breeding, roosting, or dispersal
  - For the long-term maintenance of the species or ecological community (including the maintenance of species essential to the survival of the species or ecological community, such as pollinators)
  - To maintain genetic diversity and long-term evolutionary development, or for the reintroduction of populations or recovery of the species or ecological community.

Such habitat may be, but is not limited to habitat identified in a recovery plan for the species or ecological community as habitat critical for that species or ecological community; and/or habitat listed on the Register of Critical Habitat maintained by the Minister under the EPBC Act.

10.4 Existing environment

A detailed description of the existing environment at the Nolans site is included in Chapter 9 and Appendix M and N.

Fauna habitats across the study area have been subdivided into vegetation types that are technically different from each other botanically (see Appendix M for detailed information), but for fauna they can more broadly be grouped into six habitat types:

- Mulga woodland
- Spinifex grassland on sandplain
- Rocky rises
- Acacia and mallee shrubland/woodland
- Riparian woodland
- Non-spinifex grassland (occasionally with sparse open woodland).

These fauna habitats are described in more detail in Appendix M and N, including a description of their occurrence within the study area, their habitat attributes and their relationship to the different vegetation communities.

The existing environment as it relates specifically to listed, threatened species includes the following features:

- Predation, which is likely to be an important threat to some threatened species in the bioregion, including the Black-footed Rock-wallaby
- Changes to fire regimes, which are likely to be an important threat to some threatened species in the region
- Grazing by livestock and/or feral animals, which is likely to impact threatened species in the region including the Black-footed Rock-wallaby.

10.5 Methodology

10.5.1 Desktop review

The Commonwealth DotE Protected Matters Search Tool (PMST) was used to identify MNES potentially occurring within the study area. The PMST considers fauna species and communities listed under one or more provisions of the EPBC Act, and is based on predicted distributions of fauna species and communities and/or their habitat, rather than known records. Thus the PMST may predict the occurrence of a species or community in an area when there are no documented records from the area.

The DLRM Fauna Atlas database results were interrogated to identify actual records of all fauna species known to occur (rather than predicted to occur) within 10 km of the study area.

Scientific literature reviewed provided background information on the biology and conservation status of the threatened species. These species are often rare, cryptic and/or sparse, and require targeted and non-standard survey methods to maximise the chances of detection.

During the course of the fauna assessments for this project, the DoE made changes to the threatened species lists considered under the EPBC Act. Two of these changes concern species identified for this project; Brush-tailed Mulgara and Southern Marsupial Mole. Both species were assessed as EPBC listed, threatened species at the time of the field assessments, but neither is now listed as threatened under the EPBC Act, so both have been removed from this Chapter of the EIS. This is discussed in more detail in Appendix N.

10.5.2 Field assessment

Field surveys targeting the threatened species were undertaken at Nolans site between 2011 and 2015.

Table 10-1 provides a summary of the timing of surveys and level of effort applied.

Table 10-1 Targeted survey schedule and brief description

Timing	Team	Extent of survey	Brief description
8 – 9 December 2011	Two GHD zoologists	Diurnal surveys targeting Black-footed Rock-wallaby in and around the Nolans Bore mine site in areas of rocky habitat. Intensive spotlighting searches were undertaken in an effort to detect the Greater Bilby (*Macrotis lagotis*) in and around the Nolans Bore mine site.	Investigating areas of potential rock-wallaby habitat, collecting potential rock-wallaby scat, and photographing suitable rock-wallaby shelter habitat using a GPS camera.
21 – 23 July 2015	Three to five GHD ecologists/rangers including Dr Rachel Paltridge (Desert Wildlife Services)	Borefield area survey was undertaken to detect the presence of Great Desert Skink and Greater Bilby in the proposed access roads and water pipeline corridors (see Figure 10-1).	Daylight surveys walking along the transect corridor approximately 5-10 m apart scanning the ground for signs of the threatened species such as scat, burrows, diggings and/or latrines.
23 – 26 July 2015	Three GHD ecologists and Dr John Read (Ecological Horizons)	Targeted surveys for Black-footed Rock-wallaby over a 65,000 ha area in the eastern end of the Reynolds Range, Hann Range, Reaphook Hills and outcrops in between, targeting rocky outcrops, steep slopes, food plant areas(see Figure 10-2).	Surveys were conducted on foot in teams of two during daylight hours. Teams were dropped onto rocky outcrops by helicopter and surveyed sites for approximately one hour at each site.

10.5.3 Survey techniques

The following section describes the survey techniques that were utilised in targeted searches to detect presence of EPBC listed, threatened fauna species. Figure 10-1 illustrates the survey effort for the associated fauna species.

Borefield area survey

The borefield area surveys were primarily targeting the Great Desert Skink and Greater Bilby. A single Great Desert Skink burrow system was identified in the borefield area during baseline fauna survey.

Survey was conducted during daylight hours, with three to five ecologists and rangers on foot traversing the disturbance corridor, approximately 5-10 m apart and scanning the ground for signs of the threatened species such as scat, burrows, diggings and/or latrines. The total length of corridor surveyed was 37.4 km (see Table 10-1).

Targeted surveys for Great Desert Skink (Liopholis kintorei)

The surveying of burrow entrances may be more profitable in warmer months as the species is more active in the warmer weather. Watching burrows in cooler times of the year may involve setting up motion-sensing cameras to 'watch' for longer periods. McAlpin (2001b) reports the optimum time of year for monitoring burrows as late summer and early autumn, before the lizards enter hibernation, at which time the maximum number of individuals are likely to inhabit the burrow systems.

Burrows were observed during July 2015 which is a cooler time of the year and required setting up motion-sensing cameras to 'watch' for longer periods.

Additional searches were undertaken around the Great Desert Skink burrow previously recorded during the May 2015 baseline fauna survey. Four remote sensor cameras were set up, with the aim of obtaining images of the skinks when they become active again as the weather warms in September. Cameras were collected on the 22 October 2015 and contained images of Great Desert Skink.

Targeted surveys for Greater Bilby (Macrotis lagotis)

Spinifex-dominated habitats within the study area provide potential habitat, including areas with low shrub cover.

Recommended survey techniques include habitat assessments, searching for signs of activity, collection of predator scats and soil plot surveys (tracks). Spotlight or camera surveys at burrow entrances may be effective following detection of signs. Spotlight surveys from a vehicle allowing large distance to be covered through suitable habitat are also effective.

Extensive and intensive nocturnal (spotlighting) searches were undertaken on foot and from slow-moving vehicles to detect active individuals of this species in 2010/11 and again in 2015.

In 2015 diurnal searches of the borefield area were also undertaken to locate potentially suitable habitat and signs of potential activity, including burrows, tracks, scats and diggings.

Motion-sensing cameras were used in selected locations of suitable habitat and where possible Greater Bilby diggings/burrows were found.

Targeted surveys for Black-footed Rock-wallaby (Petrogale lateralis MacDonnell Ranges race)

Surveys concentrated on rocky outcrops, crevices, caves and boulder piles where rock-wallabies typically shelter, and vegetated parts of hills and escarpments, particularly grassy areas, where rock-wallabies potentially forage (see Figure 10-2).

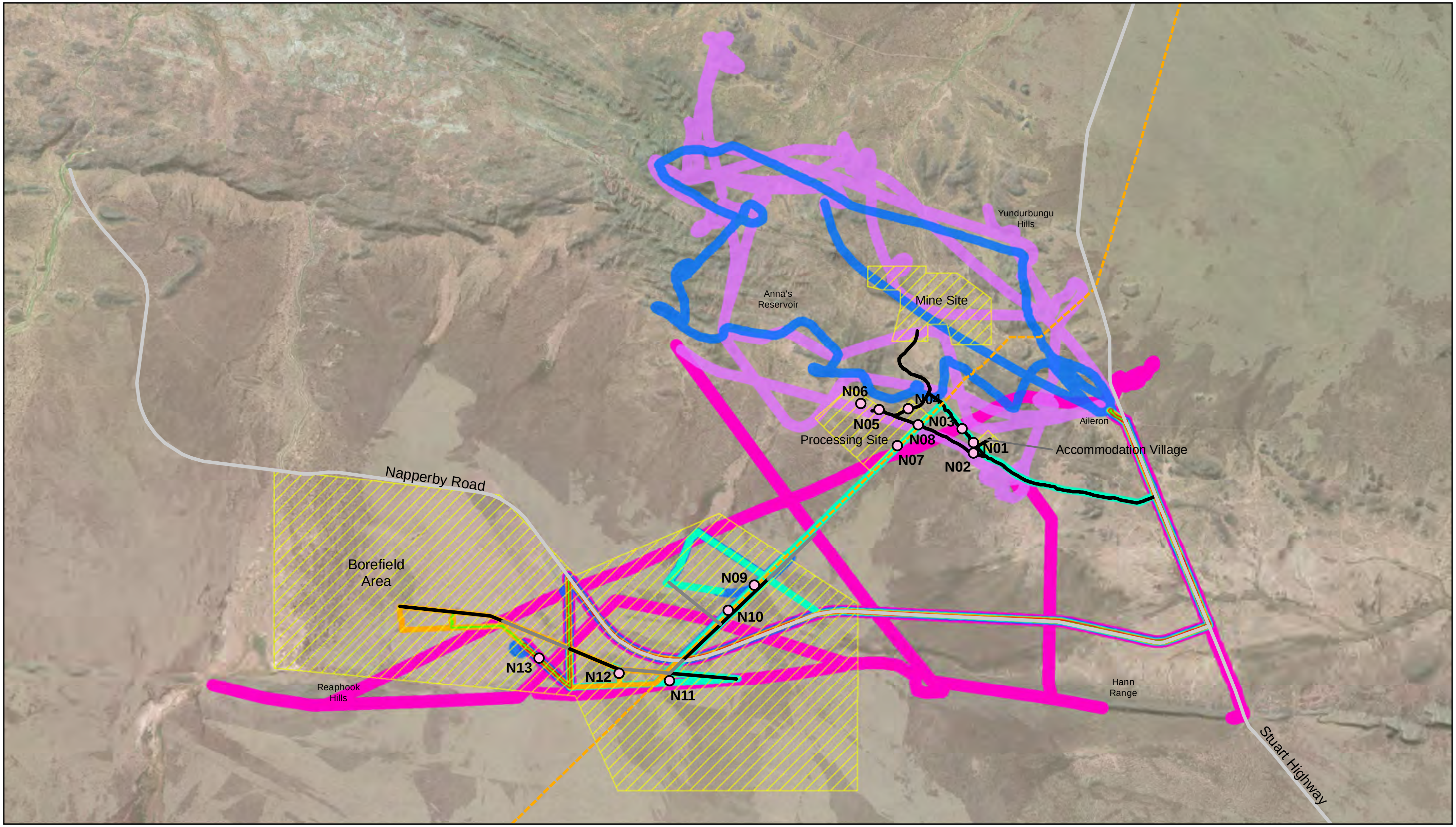
Low densities of Black-footed Rock-wallabies can be difficult to detect using ground-based diurnal or spotlighting surveys. Searching for scats is a reliable and repeatable technique for detecting populations. Macropod scats were collected for analysis.

During baseline fauna survey in September 2010, the survey team detected the Black-footed Rock-wallaby in the rocky habitats of the mine site area. In December 2011, diurnal surveys were undertaken by two ecologists over two days, in and around the mine site.

In July 2015, 65 survey sites were spread over a 650 km^2 area in the eastern end of the Reynolds Range, Hann Range, Reaphook Hills and many small outcrops in between.

Surveys were conducted on foot, in teams of two, during daylight hours. Teams were dropped into sites by helicopter. A habitat assessment was completed at each site, including qualitative notes on presence/abundance, likely shelter/refuge sites (e.g. caves, crevasses or large boulder piles), proximity to forage and vegetative cover (especially figs, spearbush and grassy patches).

All scat identifications were verified by Dr John Read (Ecological Horizons) from the SA Warru Recovery Team. Scats collected were lodged with the Museum and Art Gallery of the Northern Territory.



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0 2 4 6 8 10

Kilometres

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

N

LEGEND

- Fauna Sites
- Roads
- Gas Pipeline
- Access Roads
- Study Area
- Day 1
- Day 2
- Day 3
- Day 4
- Day 5
- Day 6
- Day 7

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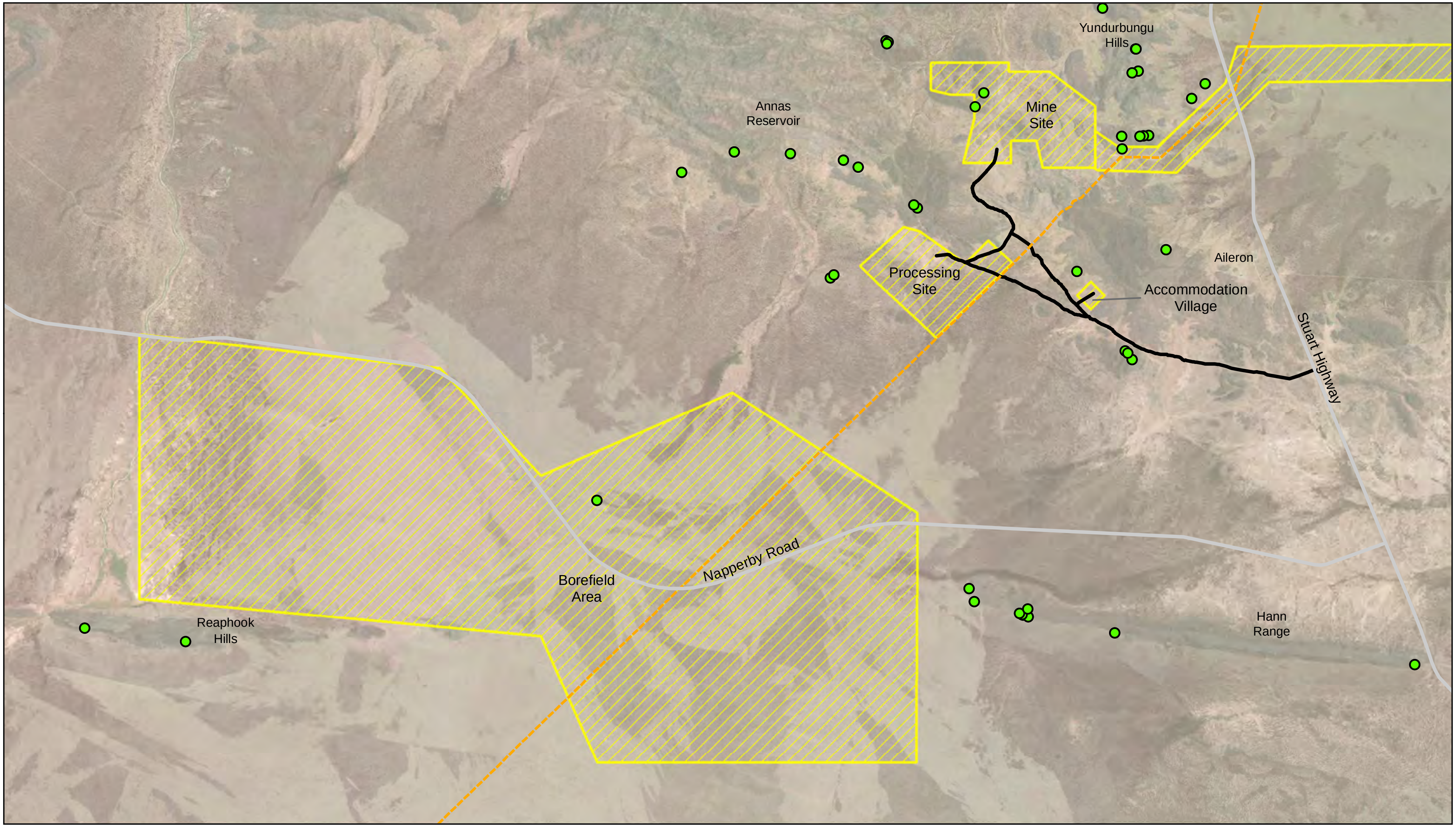
Survey effort for 2015 targeted fauna surveys

Figure 10-1

G:\43\22301\GIS\Maps\4322301_031_SurveyEffortJuly2015.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: GA - Imagery (2008), Roads, Gas Pipeline (2015). GHD - Fauna Survey Sites, Proposed Mine Site, Proposed Treatment Plant, Proposed Accommodation Village, Borefield Area (2015). Created by: CM



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0 2 4 6 8

Kilometres

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

N

LEGEND

- Black-Footed Rock-Wallaby Survey
- Roads
- Gas Pipeline
- Access Roads
- Study Area

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Nolans Project
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Revision	0
Date	18 Mar 2016

Black-footed Rock-wallaby survey sites

Figure 10-2

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: GA - Roads, Gas Pipeline, Imagery (2015). GHD - Study Area, Black-footed rock-wallaby data (2015). Created by: CM

10.6 Results of targeted threatened species survey

10.6.1 Desktop assessment

Listed threatened fauna species are listed under one or more categories of threat (i.e. vulnerable, extinct, near threatened) under the EPBC Act.

Counts of EPBC listed fauna species identified for the Nolans site are presented in Table 10-2. Note that all species listed under the EPBC Act are also listed under the TPWC Act. Species which are listed under the TPWC Act and not the EPBC Act are discussed in Chapter 9 of this EIS.

More than half of the EPBC Act listed threatened species identified for the area are mammals (16 species), and of those, nearly half (seven species) are considered to be extinct in the Northern Territory or across the whole of Australia. The other threatened species are made up of birds (five species) and reptiles (one species). No frogs in the area are currently listed as threatened.

Table 10-2 Counts of fauna species (by group) identified for the study area that are listed in categories of threat

Species group / Threat category	Mammals	Birds	Reptiles	Frogs	Total
EPBC Act					
Extinct (EX)	7	0	0	0	**7**
Endangered (EN)	4	2	0	0	**6**
Vulnerable (VU)	5	3	1	0	**9**
Total (EPBC Act)	**16**	**5**	**1**	**0**	**22**

10.6.2 Threatened species – known and expected occurrence within study area

There are a range of terrestrial habitats in the study area, and each is mostly in good condition. Based on the typical habitat requirements and geographic distribution of the listed species, the study area is considered capable of providing at least some habitat for most of them.

The EPBC listed species are listed in Table 10-4 along with their conservation status and a summary of their potential use of the study area (likelihood of occurrence). Note that threatened species would be expected to use the Nolans site in varying ways, from breeding residents to occasional, frequent, seasonal, irregular, rare or vagrant visitors.

Table 10-3 EPBC listed species identified in the study area

Species	Mine site area	Accomm area	Processing site	access road to Stuart Hwy)	Utilities corridor (north)	Utilities corridor (south)	Borefield area
MAMMALS							
Greater Bilby (EPBC)	P	P	P	P	P	P	P
Black-footed Rock-wallaby (EPBC)	K		K				K
BIRDS							
Princess Parrot (EPBC)		P	P	P	P	P	P
REPTILES							
Great Desert Skink (EPBC)			P			P	K
Count (EPBC-listed species)	**2**	**2**	**3**	**2**	**2**	**3**	**3**

Key:

K – known to occur in this section of the study area;

P – occurrence possible in this section of the study area.

Blank grey cells indicate that a species is unlikely to occur in that section on the basis of dominant habitat in that section (but do not mean that species are absent).

Species listed under the EPBC Act are indicated as 'EPBC'.

For the utilities corridor, "north" and "south" refer to north and south of the processing site. Utilities corridor includes potable water and process water pipelines, powerlines and adjacent access track

10.6.3 Threatened fauna species most likely to be impacted by the Project

Four EPBC listed fauna species are given special attention based on the likelihood of occurrence assessment and are highlighted in Table 10-4 below.

If the Project results in significant residual impacts on any species listed as threatened under the EPBC Act, then compensatory offsets may be required under the EPBC Act, in accordance with DSEWPaC (2012). According to the EPBC Act website, offsets are 'measures that compensate for the residual impacts of an action on the environment, after avoidance and mitigation measures are taken.

Additional information for these species is provided in sections below.

Table 10-4 Threatened EPBC species within the survey area and likelihood of occurrence

Species	EPBC	Where detected? (GHD surveys)	Likely Extent of occurrence within the study area
MAMMALS			
Black-footed Rock-wallaby (MacDonnell Ranges race) *Petrogale lateralis*	VU	Mine site and borefield	Mine site and scattered outcrops in the borefield. Species restricted to steep rocky habitats, particularly the larger rock outcrops and ranges.
Greater Bilby (Bilby) *Macrotis lagotis*	VU	(Not detected)	Potentially suitable habitat occurs across much of the study area, but particularly in the southern areas that are dominated by sandplain.
BIRDS			
Princess Parrot *Polytelis alexandrae*	VU	(Not detected)	Potentially suitable habitat occurs across much of the study area, particularly in the southern areas that are dominated by sandplain.
REPTILES			
Great Desert Skink *Liopholis kintorei*	VU	Borefield area	Detected as burrow/latrine system, with identification of scats verified. May occur across much of the sandplain habitat in the south of the study area.

Key:

VU = vulnerable

Black-footed Rock-wallaby MacDonnell Ranges race (Petrogale lateralis)

Signs of Black-footed Rock-wallaby (Plate 10-1) were widespread across the broader study area, which indicates that this species is present, at least in small numbers. Based on observations of scat abundance and freshness, wallabies appear to favour some sites over others, and appear to have used some sites more recently than others. Evidence of juveniles at a small number of sites indicates that rock-wallabies are likely to be breeding in the area, or possibly dispersing through the area, but suggests that breeding/rearing does not occur in all areas, and may be limited to the most favourable habitat (e.g., abundance of food or safety from predators).

When assessed against vegetation, other fauna, fire history, distance to water and distance to higher quality habitat, patterns in rock-wallaby distribution were obscure and difficult to interpret. A larger and more comprehensive study of rock-wallaby ecology would be required to confidently explain the distribution of the species in the rocky hills that surround the mine site area.

However, most areas where Black-footed Rock-wallaby were recorded are not within the footprint of the mine or associated infrastructure corridors (although fresh scat and juvenile scat was recorded within a distance of approximately 2 km from the mine site). Therefore, direct impacts on this species are expected to be minimal, although indirect impacts on the population may occur throughout the broader area through increases in the prevalence of wildfire and introduced predators, which may be a consequence of the Project. Mitigation measures will be put in place to minimise the effects of these impacts.

Plate 10-1 Black-footed Rock-wallaby (Photo taken at Finke Gorge National Park, NT)

Great Desert Skink (Liopholis kintorei)

One Great Desert Skink (*Liopholis kintorei*) burrow system was found during the 2015 baseline fauna survey (Table 10-3) in the borefield, with a possibility of occurrence in the southern utility corridor and processing site. It was in habitat that appeared not to have been burnt very recently, but had been burnt recently enough that the spinifex tussocks were large but not very large (perhaps burnt within the past 5-6 years).

The DLRM NT Fauna Atlas results (June 2015) indicate that the species has also previously been recorded in the borefield area in the vicinity of the Napperby Road but the record is undated. All parts of the study area that are spinifex-dominated sandplain provide potentially suitable habitat for this species, but areas that have larger and more established spinifex (perhaps as a result of less frequent fire) are most likely to support burrow systems.

Targeted surveys for Great Desert Skink burrows were completed during the 37.4 km of walking transects of the proposed alignments, and intensively within 200 m of the known Great Desert Skink burrow identified previously in 2015 and an historic record three kilometres north of the proposed alignment close to the Napperby Road. No signs of Great Desert Skink were detected along the proposed access roads and water pipeline corridor, or in the area surrounding the historic record. No additional burrow systems were found in the area around the known Great Desert Skink burrow.

Four separate remote fauna cameras were established at the Great Desert Skink warren during the July 2015 survey and left *in situ* until they were collected in late October 2015. Great Desert Skinks first emerged from the burrows in mid-September (Plate 10-2) and remained active up until the cameras were collected in late October.

Plate 10-2 Great Desert Skink image captured using remote sensor cameras collected on 22 Oct 2015

Greater Bilby (Macrotis lagotis)

Extensive and intensive spotlighting searches were undertaken in 2010/11 and in 2015 and walking transects along all linear infrastructure corridors (access roads, pipelines etc.) in 2015 in an effort to detect active individuals of this species. This species was not recorded during the 2010/11 or 2015 surveys, and no historical records exist for the study area. However, spinifex-dominated habitats within the study area provide potential habitat, including rocky areas and areas with a low shrub cover.

Surveys for Greater Bilby burrows were completed during the 37.4 km of walking transects of the proposed alignments, and from the air by helicopter when flying over areas of sandplain during rock-wallaby surveys. No signs of Greater Bilby were detected along the proposed access roads or service corridors.

This species was not recorded during the targeted surveys, and no historical records exist for the study area, however spinifex-dominated habitats in the borefield area provide potential habitat, including rocky areas and areas with a low shrub cover.

Princess Parrot (Polytelis alexandrae)

This species was not recorded during the 2010 or 2015 surveys, and no records exist for the study area. Suitable habitat is present within the study area, but the species is generally rare and highly mobile, and is considered to be, at most, an occasional visitor to the study area. Consequently, targeted surveys are not considered necessary for this species.

If the species is observed within the study area at any stage during the project, then that information should be made known to the NT DLRM and DotE.

10.6.4 Migratory species

Eight fauna species identified for the study area are listed as Migratory under the EPBC Act. These are listed in Table 10-5 with an evaluation of each species' likelihood of occurrence in the study area.

Two of the Migratory species (Fork-tailed Swift, *Apus pacificus* and Rainbow Bee-eater, *Merops ornatus*) are likely to occur within the study area, and one of those (Rainbow Bee-eater, *Merops ornatus*) was detected during the 2010 surveys.

Habitats within the study area are unlikely to be considered 'important habitat', and the birds that occur there are unlikely to be an 'ecologically significant population' (in accordance with the EPBC Act). The Project is not expected to impact on any listed migratory species.

Table 10-5 Fauna species identified for the study area and listed as Migratory under the EPBC Act

Species	Likelihood of occurrence within study area
Migratory Marine Birds	
Fork-tailed Swift *Apus pacificus*	Possible – All areas
Migratory Terrestrial Species	
Rainbow Bee-eater *Merops ornatus*	Present – all areas
Migratory Wetland Species	
Great Egret (White Egret) *Ardea alba (=modesta)*	Unlikely – All areas.
Cattle Egret *Ardea ibis*	Unlikely – All areas.
Oriental Plover, Oriental Dotterel *Charadrius veredus*	Unlikely – All areas.
Oriental Pratincole *Glareola maldivarum*	Unlikely – All areas.
Australian Painted Snipe *Rostratula benghalensis (australis)*	Unlikely – All areas.

Species	Likelihood of occurrence within study area
Glossy Ibis *Plegadis falcinellus*	Unlikely – All areas.

10.7 Potential impacts

The potential impact of the Project on MNES, specifically Black-footed Rock-wallaby (MacDonnell Ranges race) (vulnerable), Greater Bilby (vulnerable), Great Desert Skink (vulnerable) and Princess Parrot (vulnerable); has been assessed in Appendix N. The risk register for MNES (based on EPBC Significant Impacts Guidelines) has been developed separately from the whole of Project risk assessment, and is presented in Section 6.11 in Appendix N.

Evaluation of the significance of potential impacts are based on the Commonwealth's *Significant Impacts Guidelines 1.1 - Matters of National Environmental Significance* as applied to endangered and vulnerable species.

An action is likely to have a significant impact on a critically endangered or endangered species if there is a real chance or possibility that it will:

- *Lead to a long-term decrease in the size of a population*
- *Reduce the area of occupancy of the species*
- *Fragment an existing population into two or more populations*
- *Adversely affect habitat critical to the survival of a species*
- *Disrupt the breeding cycle of a population*
- *Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline*
- *Result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat*
- *Introduce disease that may cause the species to decline*
- *Interfere with the recovery of the species.*

10.7.1 Assessment of the "real chance of probability" of an EPBC significant impact

An extensive risk assessment methodology has been developed to assess the potential risk of each impact against the significant impact criteria listed in the guidelines. The risk assessment methodology specific to MNES is discussed in the following sections.

A "real chance or probability" of a significant impact from a particular source is defined as there being an extreme or high risk of a population (or the fauna community) experiencing a significant consequence as defined in the guidelines e.g. reduce the diversity or modify the composition of plant or animal species.

The initial levels of risk, and determination of residual risk (after avoidance, mitigation and management actions have been applied) have been undertaken using standard qualitative risk assessment procedures consistent with AS/NZS ISO 31000:2009 'Risk Management – Principles and Guidelines', with the exception of economic risk which is not addressed in the Guidelines.

Assessment of risk has been conducted through consideration of the circumstances around risks, identifying necessary controls to address potential impacts and assuming effective implementation of planned and committed mitigation of potential impacts.

Avoidance, mitigation and management actions are proposed in an attempt to reduce residual risk (risk after actions) where possible to below “Extreme” or “High” risk outcomes to the extent reasonably practicable as part of reducing the overall Project risk.

The depth of focus on risk controls is linked to the level of risk and opportunity for reduction to meet organisational commitments and goals linked to an environmentally and socially responsible operation, and those requirements are part of the regulatory obligations and impact assessment guidelines.

Table 10-6 and Table 10-7 provide a summary of the qualitative risk matrix adopted and the levels of risk for the various consequence and likelihood combinations.

Table 10-6 Qualitative Risk Analysis Matrix

Likelihood	Consequence Level				
	Insignificant (1)	Minor (2)	Moderate (3)	Major (4)	Catastrophic (5)
Almost Certain (5)	Medium	High	High	Extreme	Extreme
Likely (4)	Medium	Medium	High	High	Extreme
Possible (3)	Low	Medium	Medium	High	High
Unlikely (2)	Low	Low	Medium	Medium	High
Rare (1)	Low	Low	Low	Medium	Medium

Table 10-7 Definitions of levels of consequence

Levels of Consequence	Definitions
Catastrophic	Moderate or substantial regional decrease in size of population(s) of listed fauna species
Major	Substantial local decrease in size of population(s) of listed fauna species
Moderate	Moderate local decrease in size of population(s) of listed fauna species
Minor	Minor local decrease in size of population(s) of listed fauna species
Insignificant	No loss of individuals of listed fauna species

10.7.2 The fauna and populations of threatened species

Each of the species to be assessed can be regarded as having a “population” in the Nolans site area. The populations of each of the threatened species occupy specific areas in and around the study area as defined by the species’ preferred habitats and biology. Areas occupied/possibly occupied by the fauna and population of each species are unlikely to be related to boundaries imposed by the mine site/borefield boundaries or processing site.

This assessment is risk averse in that two of the species were not recorded during the study.

The areas occupied by the populations/the entire fauna are:

- Black-footed Rock-wallaby is known (from July 2015 targeted survey) to occur throughout the rocky habitats of the eastern parts of the Reynolds Range which incorporates the study area. Only transient populations appear to occur within the actual mine site footprint, however a viable population was found to occur in the immediate vicinity of the mine site with 20 sites found to contain fresh rock-wallaby scat and 25% of those sites containing juvenile scat (of 65 sites visited, 35 contained rock wallaby scat, 20 sites had fresh scat and 5 of the 20 had juvenile scat)
- The Great Desert Skink was only recorded on one occasion in the far south-west of the proposed borefield. Although only one active Great Desert Skink warren was recorded, despite extensive searches of the proposed borefield (i.e. 37.4 kms walking transect along proposed borefield pipeline network using a minimum of three ecologists), it is possible that this species could occur within any of the sandplain habitats of the study area (e.g. one other historic record for this species also exists in the borefield)
- The Greater Bilby was not recorded during the previous surveys (despite a distance of 37.4 km covered by three ecologists in addition to aerial surveys looking for burrows) and there are no historic records within the proposed Project footprint, however it is possible that this species could occur within any of the sandplain habitats of the study area
- The Princess Parrot was not recorded during the previous surveys and there are no historic records within the proposed Project footprint, however it is possible that this species could occur within any of the habitats within the proposed Project footprint apart from the rocky habitats.

The entire fauna is assumed to be broadly present within the Burt Plain Bioregion within their preferred habitats as described above. In reality the fauna and its threatened species extend much further than that considered in the assessments.

Sources of impact (events/activities/actions) arising from the proposed Project that have the potential to have a significant impact include:

- Clearing of breeding and/foraging habitat (includes harming or killing of animals directly)
- Dust generated by construction, mining and processing activities
- Noise generated by construction, mining and processing activities
- Wildfire that may result unintentionally from construction, mining and processing activities
- Introduction and/or spread of exotic plants and animals
- Poisoning of fauna from drinking water in the tailings and/or residue storage facilities
- Lowering or contamination of the water table
- Artificial light generated by mining and processing activities
- Injury and death of fauna from collisions with vehicles.

Each of these potential sources of impact is addressed in more detail below. Table 10-8 and Table 10-9 provide a summary of the level of residual risk associated with these potential sources of impact.

Table 10-8 Project Risk – Black-footed Rock-wallaby species present within the mine site and within the vicinity

Source of Impact	Likelihood	Consequence	Severity	Residual Risk (following additional implementation of mitigation measures)
Clearing – dispersal and foraging habitat	Unlikely	Minor	Low	Low
Dust	Unlikely	Insignificant	Low	Low
Noise	Unlikely	Insignificant	Low	Low
Light	Unlikely	Minor	Low	Low
Unplanned Wildfire	Possible	Major	High	Medium
Exotic plants and animals	Possible	Major	High	Low
Waste water	Rare	Insignificant	Low	Low
Lowering or contamination of water table	Rare	Insignificant	Low	Low
Traffic mortality	Rare	Insignificant	Low	Low

Table 10-9 Project Risk – Great Desert Skink, Greater Bilby, Princess Parrot species present within the borefield and adjacent access corridor

Source of Impact	Likelihood	Consequence	Severity	Residual Risk (following additional implementation of mitigation measures)
Clearing – dispersal and foraging habitat	Unlikely	Minor	Low	Low
Dust	Unlikely	Insignificant	Low	Low
Noise	Unlikely	Insignificant	Low	Low
Light	Unlikely	Minor	Low	Low
Unplanned Wildfire	Possible	Major	High	Medium
Exotic plants and animals	Possible	Major	High	Low
Waste water	Rare	Insignificant	Low	Low

Lowering or contamination of water table	Rare	Insignificant	Low	Low
Traffic mortality	Possible	Minor	Medium	Low

The following risk assessment tables associated with each of the aforementioned potential impacts are derived from the fauna report (Appendix N). Each table presents the risk assessment for

- the Black-footed Rock-wallaby, in areas within and around the mine site
- Great Desert Skink, Greater Bilby, Princess Parrot within the borefield and access corridor.

10.7.3 Clearing of breeding and/or foraging habitat

The figures provided below are highly conservative in that the total areas of clearing presented below indicate broad areas of habitat that may not completely represent preferred habitat (e.g. for rock-wallaby, the 266.23 ha of rocky habitat proposed for clearing is not all likely to be high quality habitat).

Black-footed Rock-wallaby

A total cumulative loss (all vegetation communities) of 266 ha of known foraging and dispersal habitat. This equates to broadly 0.41% of the 65,000 ha of potential habitat within the 150,000 ha search area from the July 2015 survey.

The habitat to be lost within the Project footprint appears to be foraging/dispersal habitat only (old scats present) compared to the foraging/breeding/dispersal habitat within the surrounding Reynolds Range in the vicinity of the proposed mine site survey.

The overall risk of the potential impact has been assessed against the significant impact criteria in Table 10-10 below.

Table 10-10 Risk assessment of the potential impact of clearing of breeding and/or foraging habitat on the Black-footed Rock-wallaby

Significant impact criteria	Likelihood	Consequence	Minimising, mitigation and management actions	Residual risk
Lead to a long-term decrease in the size of a population.	2	2	- Develop and apply dedicated Biodiversity Management Plan (BMP) to minimise and mitigate clearing effects on the Black-footed Rock-wallaby - Monitor the impact that clearing has on the	Low
Reduce the area of occupancy of a population	1	2		Low
Fragment an existing important population into two or more populations	2	2		Low
Adversely affect habitat critical to the survival of a species	2	1		Low
Disrupt the breeding cycle of a population	2	1		Low

Significant impact criteria	Likelihood	Consequence	Minimising, mitigation and management actions	Residual risk
Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	2	2	Black-footed Rock-wallaby population	Low
Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat	2	2		Low
Introduce disease that may cause the species to decline	1	1		Low
Interfere with the recovery of the species	2	2		Low

Great Desert Skink, Greater Bilby and Princess Parrot, species present within the borefield

The Great Desert Skink in the study area to lose:

- A total cumulative loss (all vegetation communities) of 122.25 ha of known foraging/breeding/dispersal habitat. This equates to broadly 0.29% of the approximately 41,568 ha of potential habitat within the sandplain habitats of Napperby and Aileron stations that encompass the Nolans Project.
- There is more extensive potential habitat in the Burt Plain Bioregion in addition to this area. A single Great Desert Skink active warren was recorded in the far south-west of the study area that is currently situated outside of the proposed development area for the borefield. It will be important to avoid this location during the construction and operation of the project.

The Greater Bilby in the study area to lose:

- A total cumulative loss (all vegetation communities) of 122.25 ha of possible foraging/breeding/dispersal habitat. This equates to broadly 0.29% of the approximately 41,568 ha of potential habitat within the sandplain habitats of Napperby and Aileron stations that encompass the Nolans Project. There is certainly much more extensive potential habitat in the Burt Plain Bioregion in addition to this area
- This species was not recorded during any of the previous surveys conducted within the study area (including aerial flyover of habitat looking for burrows). Despite not being detected, this species is mobile and could still occur in very low abundance (thus difficult to detect). Impacts would likely be low with the primary impacts being vehicle strike at night (low likelihood) and increased predation due to greater presence of people and their waste (i.e. increase in predator abundance).

The Princess Parrot in the study area to lose:

- A total cumulative loss (all vegetation communities) of 362.21 ha of possible foraging/dispersal habitat. This equates to broadly 0.87% of the approximately 41,568 ha (borefield). There is certainly much more extensive potential habitat in the Burt Plain

Bioregion in addition to this area. This species is highly nomadic and would be an occasional visitor to the study area at most.

- This species was not recorded during any recent or previous surveys in the study area. As mentioned, this species is highly nomadic and irruptive in response to rainfall and improved conditions. This species arrived at Newhaven Station in 2012 (approx. 180 km from the study area) following good rainfall in central Australia. It is possible that this species could visit the study area under similar conditions in the future.

The overall risk of the potential impact has been assessed against the significant impact criteria in Table 10-11 below.

Table 10-11 Risk assessment of the potential impact of clearing of breeding and/or foraging habitat on the borefield species

<table>
<tr><th>Significant impact criteria</th><th>Likelihood</th><th>Consequence</th><th>Minimising, mitigation and management actions</th><th>Residual risk</th></tr>
<tr><td>Lead to a long-term decrease in the size of a population.</td><td>2</td><td>2</td><td rowspan="7">- Importantly for species such as the Great Desert Skink, avoid the known active warren for this species, implement clearing during autumn when breeding has ended. For borefield fauna in general, avoid clearing during the winter/spring months when animals (particularly reptiles) are inactive in burrows or breeding. A qualified ecologist on-site during the clearing would capture and translocate animals encountered during the clearing process;
- Develop and apply dedicated Biodiversity Management Plan (BMP) and ensure appropriate construction, weed, weed hygiene, fire and rehabilitation management aspects are covered in an attempt to minimize and mitigate clearing effects.
- As part of BMP incorporate a monitoring program for threatened species (particularly Great Desert Skink) to monitor the impact that clearing has on local populations;</td><td>Low</td></tr>
<tr><td>Reduce the area of occupancy of an important population</td><td>4</td><td>1</td><td>Low</td></tr>
<tr><td>Fragment an existing population into two or more populations</td><td>2</td><td>2</td><td>Low</td></tr>
<tr><td>Adversely affect habitat critical to the survival of a species</td><td>2</td><td>2</td><td>Low</td></tr>
<tr><td>Disrupt the breeding cycle of a population</td><td>2</td><td>2</td><td>Low</td></tr>
<tr><td>Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline</td><td></td><td></td><td>Low</td></tr>
<tr><td>Result in invasive species that are harmful to a vulnerable species becoming established in the</td><td>3</td><td>2</td><td>Low</td></tr>
</table>

Significant impact criteria	Likelihood	Consequence	Minimising, mitigation and management actions	Residual risk
vulnerable species' habitat				
Introduce disease that may cause the species to decline	1	1		Low
Interfere with the recovery of the species	2	2		Low

The areas to be cleared will form small islands of cleared habitat in a near continuous area of native vegetation. The area is bounded to the south by the Reaphook Hills and Hann Range and Stuart Highway to the east. The proposed mining will not cause any fragmentation of the habitat.

The proposed loss of habitat for these threatened species and the entire fauna are relatively small compared to the actual study area over which the faunal populations are distributed and potentially occur within the area assessed (approx. 150,000 ha by both vehicle and helicopter) and broader region which includes the eastern end of the Reynolds Range, Napperby and Aileron stations.

Clearing seems unlikely to have any significant direct impact on any of the threatened species and populations.

The fauna as a whole is similarly likely to experience no significant effects from the clearing itself with other impacts discussed below such as vehicle strike and the introduction of exotic predators likely to be more important for future management. Impacts from the clearing would likely be minimal, and not amenable to detection at the population level.

Specific mitigation measures would need to be implemented for species with very small known populations such as the Great Desert Skink active warren in the south-west of the study area. The active warren is not currently part of the proposed development and this would need to remain so, with protection of this location.

General mitigation measures

To minimise and mitigate clearing effects on threatened species populations, breeding habitat and foraging habitat the following actions have been considered:

- Subtle realignment and preliminary design and -siting of all infrastructure to minimise loss of key breeding and feeding habitat (particularly in the borefield to avoid the Great Desert Skink warren)
- Clearly marking areas of land to be cleared and areas to be retained (No-Go areas), so that impacts do not extend any further than necessary into important habitat
- Construction and clearing during non-breeding period (e.g. clearing to occur preferably in autumn when young animals are mobile and less dependent on parents and when reptiles are still active and have a chance to escape)

- Consider a cool, well managed fuel reduction burns of all habitats to be cleared to allow fauna to have the chance to escape prior to chaining of vegetation and bulldozing up into windrows. Details on this approach would be contained within a BMP
- Pre-clearing fauna surveys prior to construction of the mine with qualified ecologists on site to capture and translocate animals that are found during the clearing process
- Strict vehicle hygiene protocols to prevent new weed incursion and spread, including a vehicle wash down facility on site
- Strict fire prevention management protocols to prevent wildfire during clearing activities
- Possibly offsetting habitat at a higher quantum and condition, the habitat to be cleared, including actions to manage offset areas to decrease threatening processes, and increase threatened species populations. Details on this approach would be contained within a BMP
- Rehabilitation of edges (of clearing) abutting threatened species habitat to remove weed species, and maximise the presence of native plant regeneration
- Monitoring of habitat clearing to ensure compliance with areas marked as No-Go areas
- Use of already-disturbed areas (rather than undisturbed areas) wherever possible (e.g. set down areas for construction)
- Progressive and incremental clearing of land as needed, rather than large-scale clearing in advance
- Progressive rehabilitation/stabilisation of cleared land as activities are completed (which forms part of the Closure and Rehabilitation Plan)
- Ongoing pest animal control (e.g. control of cats and foxes in particular).

10.7.4 Dust generated by mining and processing activities

Dust is a potential problem for projects in regions that experience extended dry periods. Central Australia exhibits an arid and unpredictable climate that could extend for periods of months without rain.

Drilling, blasting, excavation, movement of vehicles and handling of materials results in dispersion of particulates and dust, particularly from the mine site, and consequent soil, surface/groundwater contamination.

Potential impacts of dust can include:

- Degradation/loss of fauna habitat from detrimental impacts of dust deposition on flora species and vegetation communities
- Degradation/loss of water source for fauna resulting from degradation of surface water quality due to dust deposition/sedimentation. Details of dust deposition can be found in air quality report contained in Appendix Q

Populations of Black-footed Rock-wallaby do occur within less than two kilometres of the mine site and could be subjected to levels of dust. Mitigation measures would need to be implemented to keep dust levels to a minimum.

The threatened species either do not or would not regularly occur in the vicinity of the mine site (Great Desert Skink, Greater Bilby, Princess Parrot) and hence would only ever be subjected to very low dust levels mainly from vehicles driving along gravel/dirt tracks.

The overall risk of the potential impact has been assessed against the significant impact criteria in Table 10-12 and Table 10-13 below.

Table 10-12 Risk assessment of the potential impact of dust on the Black-footed Rock-wallaby

Significant impact criteria	Likelihood	Consequence	Minimising, mitigation and management actions	Residual risk
Lead to a long-term decrease in the size of a population.	2	2	- A Dust Management Plan (DMP) will be developed and implemented to minimise dust emissions - Produce and apply dedicated BMP and ensure appropriate dust controls are in place in an attempt to minimize and mitigate dust effects on the Black-footed Rock-wallaby population of the area - As part of BMP incorporate a monitoring program for Black-footed Rock-wallaby to monitor the impact that dust has on the local population	Low
Reduce the area of occupancy of an important population	2	2		Low
Fragment an existing important population into two or more populations	2	2		Low
Adversely affect habitat critical to the survival of a species	2	2		Low
Disrupt the breeding cycle of a population	2	2		Low
Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	2	2		Low
Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat				n/a
Introduce disease that may cause the species to decline				n/a
Interfere with the recovery of the species	2	2		Low

Table 10-13 Risk assessment of the potential impact of dust on the borefield species

Significant impact criteria	Likelihood	Consequence	Minimising, mitigation and management actions	Residual risk
Lead to a long-term decrease in the size of a population.	1	1	- A Dust Management Plan (DMP) will be developed and implemented to minimise dust emissions - Produce and apply dedicated BMP and ensure appropriate dust controls are in place in	Low
Reduce the area of occupancy of an important population	1	1		Low
Fragment an existing important population into two or more populations	1	1		Low
Adversely affect habitat critical to the survival of a species	1	1		Low

Significant impact criteria	Likelihood	Consequence	Minimising, mitigation and management actions	Residual risk
Disrupt the breeding cycle of a population	1	1	an attempt to minimize and mitigate dust effects on the threatened populations of the area - As part of BMP incorporate a monitoring program monitor the impact that dust has on the threatened populations	Low
Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	1	1		Low
Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat				n/a
Introduce disease that may cause the species to decline				n/a
Interfere with the recovery of the species	1	1		Low

General mitigation measures

To minimise and mitigate the effects of dust on threatened species populations, breeding habitat and foraging habitat the following actions are recommended:

- The minimisation of dust emission controls as defined in a Dust Management Plan that includes, but is not limited to
  - Crusher dust controls to industry standards, via watering, emission screens, road sealing, chemical applications, covering of exposed loads where practicable
  - Minimising mining, hauling and vehicle travel when prevailing winds and strength of winds reach a particular trigger level that would result in spatially extensive and heavy dust deposition in surrounding habitats where practicable.
- Dust monitoring to assess dust effects with distance from the mine or dust-generating activity as per GHD Air Quality report
- Reduced vehicle speeds for high-use areas/roads
- Progressive rehabilitation/stabilisation of cleared land as activities are completed (which forms part of the Closure and Rehabilitation Plan).

10.7.5 Noise generated by mining and processing activities

Disturbance to fauna associated with generation of unexpected and/or excessive noise from mining and processing activities and during construction can result in:

- Displacement of fauna
- Disruption to nesting/roosting/foraging behaviour.

Displacement of fauna into sub-optimal habitats could increase their susceptibility to predation and competition.

Decline in fauna populations associated with increased noise levels are subject to variation among years and the interaction with and between habitat quality and population density plays a significant role in determining the nature of a decline.

It is likely that faunal communities in the immediate vicinity of the mine site and mine operations would be most acutely affected by the proposal and could experience periodic periods of high noise levels that may encourage them to move to other nearby habitats.

The Black-footed Rock-wallaby does occur within less than two kilometres of the mine site and appears to occasionally pass through the actual mine site footprint (old scat recorded adjacent to Nolans Bore). It is quite likely that noise generated by the mine could preclude rock-wallaby movements through the mine site as has occurred previously, however particularly noisy activities would likely occur during diurnal periods when rock-wallabies are sheltering and noise would be somewhat buffered by their rocky, elevated habitat.

Particularly 'high noise' activities should be prevented from occurring during the rock-wallabies' nocturnal activity period when they could potentially be most disturbed

It is envisaged that the majority of the EPBC listed threatened species that are known or have the potential to occur within the study area (Great Desert Skink, Greater Bilby, Princess Parrot) occur some distance from the mine site (less than ten kilometres) and would unlikely be effected by mine site noise.

Increased vehicle noise in the borefield could have some localised and isolated low-level impacts however most of these species are nocturnal and their activity patterns would unlikely be adversely impacted by activity in the borefield at night. Vehicle passage in this area would be infrequent for maintenance purposes and may only occur on a weekly basis in daylight hours.

The overall risk of the potential impact has been assessed against the significant impact criteria in Table 10-14 and Table 10-15 below.

Table 10-14 Risk assessment of the potential impact of noise on the Black-footed Rock-wallaby

Significant impact criteria	Likelihood	Consequence	Minimising, mitigation and management actions	Residual risk
Lead to a long-term decrease in the size of a population.	2	2	- The implementation of noise controls as defined in a Noise Management Plan – likely to include the avoidance of loud noise at night when rock-wallabies are active - Produce and apply dedicated BMP and ensure appropriate noise controls are in place in an attempt to minimize and mitigate noise effects on the Black-footed Rock-wallaby population of the area;	Low
Reduce the area of occupancy of an important population	2	2		Low
Fragment an existing important population into two or more populations	2	2		Low
Adversely affect habitat critical to the survival of a species	2	2		Low
Disrupt the breeding cycle of a population	2	2		Low
Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	2	2		Low
Result in invasive species that are harmful to a vulnerable species becoming				n/a

Significant impact criteria	Likelihood	Consequence	Minimising, mitigation and management actions	Residual risk
established in the vulnerable species' habitat			- As part of BMP incorporate a monitoring program for Black-footed Rock-wallaby to monitor the impact that noise has on the local population.	
Introduce disease that may cause the species to decline				n/a
Interfere with the recovery of the species	2	2		Low

Table 10-15 Risk assessment of the potential impact of noise on the borefield species

Significant impact criteria	Likelihood	Consequence	Minimising, mitigation and management actions	Residual risk
Lead to a long-term decrease in the size of a population.	1	1	- The implementation of noise controls as defined in a Noise Management Plan – likely to include the avoidance of loud noise at night when rock-wallabies are active - Produce and apply dedicated BMP and ensure appropriate noise controls are in place in an attempt to minimize and mitigate noise effects on the Black-footed Rock-wallaby population of the area; - As part of BMP incorporate a monitoring program for Black-footed Rock-wallaby to monitor the impact that noise has on the local population.	Low
Reduce the area of occupancy of an important population	1	1		Low
Fragment an existing important population into two or more populations	1	1		Low
Adversely affect habitat critical to the survival of a species	1	1		Low
Disrupt the breeding cycle of a population	1	1		Low
Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	1	1		Low
Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat				n/a
Introduce disease that may cause the species to decline				n/a
Interfere with the recovery of the species	1	1		Low

General mitigation measures

Minimising impacts on fauna from noise will involve:

- Minimising noise wherever possible
- Limiting high-impact noise to daylight hours only (this will reduce the impact on nocturnal fauna, which includes most of the threatened species).

10.7.6 Artificial light generated by mining and processing activities

Light plays a critical role in ecology. It determines activity levels of diurnal and nocturnal fauna, it assists predators in their hunting success, and some light sources attract invertebrate fauna that attract and are then preyed on by other fauna. Localised disturbance to nocturnal fauna associated with generation of light in mining and processing areas can cause the following impacts on fauna:

- Local displacement of fauna (i.e. nocturnal fauna move away from brightly lit areas)
- Increased susceptibility of fauna to predation (e.g. prey species find it harder to remain concealed in brightly lit areas)
- Disruption to nesting/roosting behaviour (e.g. bright lights may awaken diurnal species).
- Disorientation of migrating birds (e.g. Longcore et al. 2008)
- Attraction and disorientation of amphibians (Buchanan 2006)
- Disorientation of bats (e.g. Stone et al., 2009; Polak 2011)
- Attraction of and enhanced mortality of insects (e.g. Yoon et al., 2010; Ferreira and Scheffrahn 2011; Fox 2012)
- Alteration of bird calling behaviour (e.g. Kepempenaers et al., 2010; Loncore 2010)
- Breeding behaviour of amphibians (e.g. Baker and Richardson 2005)
- Small mammal activity rhythms (e.g. Rotics et al., 2011).

It is envisaged that the majority of the EPBC listed threatened species that are known or have the potential to occur within the study area (Great Desert Skink, Greater Bilby, Princess Parrot) occur some distance from the mine site (less than ten kilometres) and would unlikely be affected by mine site light. Increased vehicle and infrastructure lighting in the borefield could have some localised and isolated low-level impacts however, it is unknown whether artificial lighting has any adverse impacts on these species.

The Black-footed Rock-wallaby does occur within less than two kilometres of the mine site and appears to occasionally pass through the actual mine site footprint (old scat recorded adjacent to Nolans Bore, see Figure 24). It is possible that light emitted specifically from the concentrator at the mine site could impact on the nocturnal movement of rock-wallabies in the immediate vicinity of the mine site (i.e. previous rock-wallaby activity in the mine site appears to have been transitory only. Nocturnal lighting could reduce these dispersal activities in the immediate mine site vicinity). Rock-wallabies occurring at distances greater than or equal to two kilometres from the mine site are unlikely to be adversely impacted by artificial lighting, provided that lights are not directed at their habitat. The distance and buffering by the elevation and rocky habitat would diminish the penetration of the ‘brightness’ of the majority of lights that would be used for illumination purposes.

The overall risk of the potential impact has been assessed against the significant impact criteria in Table 10-16 and Table 10-17.

Table 10-16 Risk assessment of the potential impact of lighting on the Black-footed Rock-wallaby

Significant impact criteria	Likelihood	Consequence	Minimising, mitigation and management actions	Residual risk
Lead to a long-term decrease in the size of a population.	2	2	- Avoiding unnecessary lighting at night when rock-wallabies are active and keeping lighting low and directed at operations rather than surrounding habitat will assist greatly in mitigating impacts; - Produce and apply dedicated BMP and ensure appropriate lighting controls are in place in an attempt to minimize and mitigate artificial light effects on the Black-footed Rock-wallaby population of the area.	Low
Reduce the area of occupancy of an important population	2	2		Low
Fragment an existing important population into two or more populations	2	2		Low
Adversely affect habitat critical to the survival of a species	2	1		Low
Disrupt the breeding cycle of a population	2	2		Low
Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	2	1		Low
Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat	1	1		Low
Introduce disease that may cause the species to decline	-	-		NA
Interfere with the recovery of the species	2	1		Low

Table 10-17 Risk assessment of the potential impact of lighting on the borefield species

Significant impact criteria	Likelihood	Consequence	Minimising, mitigation and management actions	Residual risk
Lead to a long-term decrease in the size of a population.	2	2	- Avoiding unnecessary lighting at night when rock-wallabies are active and keeping lighting low and directed at operations rather than surrounding habitat will assist greatly in mitigating impacts;	Low
Reduce the area of occupancy of an important population	2	2		Low
Fragment an existing important population into two or more populations	2	2		Low
Adversely affect habitat critical to the survival of a species	2	1		Low
Disrupt the breeding cycle of a population	2	2		Low

Significant impact criteria	Likelihood	Consequence	Minimising, mitigation and management actions	Residual risk
Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	2	1	- Produce and apply dedicated BMP and ensure appropriate lighting controls are in place in an attempt to minimize and mitigate artificial light effects on the threatened	Low
Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat	-	-		NA
Introduce disease that may cause the species to decline	-	-		NA
Interfere with the recovery of the species	2	1		Low

General mitigation measures

The potentially negative impacts of artificial light can be mitigated by:

- Limiting artificial light to areas where it is essential
- Turning off lights when not required
- Limiting the escape of light into surrounding areas of fauna habitat (i.e., using shields/deflectors)
- Ensuring that artificial lighting is not directed upwards or laterally (i.e. should be directed towards the ground)
- Using lower rather than higher lighting installations
- Using lower wavelengths of light wherever possible, i.e. red/yellow lights
- Using light intensities that are as low as possible without reducing safety or efficiency
- Avoiding painting large structures bright or reflective colours and minimise use of bright or reflective construction materials and finishes for large structures.

10.7.7 Unplanned bushfire

Bushfire has an influential role in arid zone ecology, and is a necessary ecological process in some habitats. Fire can benefit some disturbance-tolerant species, but can have detrimental impacts on other types of fauna and fauna habitat, if it occurs at the wrong time of year, or in habitats that don't respond well to fire, or with excessive heat.

This Project introduces a range of potential sources of fire. Vehicles, machinery, hot works, switchgear, transformers, HV power and personnel provide potential ignition sources that could lead to fire. Impacts of fire on fauna include:

- Killing/injuring fauna
- Displacement of fauna
- Disruption to nesting/roosting/foraging habitats and/or behaviour
- Reduction of area of fauna habitat locally and/or regionally

- Habitat fragmentation
- Subsequent erosion and sedimentation resulting from loss of vegetation
- Degradation of surface water quality due to erosion of soils and landforms.

The impacts of too frequent, hot and extensive fires are well documented in the arid zone of central Australia (Woinarski et al. 2007). A number of the threatened species recorded within the study area are adversely affected by too frequent and extensive fires. Large-scale, intense wildfires from a lack of patch burning can devastate or fragment local populations of Great Desert Skink (Woinarski et. al. 2007). Wildfire within Black-footed Rock-wallaby habitat is also a major impact on populations as it burns food plants such as Spearbush and fig rendering habitats unsuitable for periods of time (Dr J. Read pers. comm.).

It is expected that all of the threatened species either known or potentially occurring within the study area would be affected by fire (both positive and negative impacts).

Controlled and strategic cool patch burns of spinifex sandplain habitat could have positive outcomes for species such as Greater Bilby (promotes food plants). Extensive burns (not patchy) of Great Desert Skink and Black-footed Rock-wallaby habitat could be detrimental as the fire would remove important shelter and food resources.

Burning of rocky habitat is unlikely to be beneficial for many species and should be avoided as there are some excellent examples of long-unburnt rocky habitats supporting species such as pine and mulga that should continue to be protected. Continued persistence of the Black-footed Rock-wallaby in the area will depend on prevention of wildfire in the surrounding rocky habitats of the study area and surrounds.

As mentioned above, too frequent, hot and extensive wildfire is unlikely to benefit any of the threatened species in the study area and surrounds, whereas localised cool patch burns are likely to be beneficial.

The overall risk of the potential impact has been assessed against the significant impact criteria in Table 10-18 and Table 10-19.

Table 10-18 Risk assessment of the potential impact of unplanned wildfire on the Black-footed Rock-wallaby

Significant impact criteria	Likelihood	Consequence	Minimising, mitigation and management actions	Residual risk
Lead to a long-term decrease in the size of a population.	2	2	- A separate Bushfire Management Plan will be required to manage this risk; - Produce and apply dedicated BMP and ensure appropriate wildfire controls are in place in an attempt to minimize and mitigate the potential 'High' impacts on the Black-footed Rock-wallaby population of the area;	Low
Reduce the area of occupancy of an important population				
Fragment an existing important population into two or more populations				
Adversely affect habitat critical to the survival of a species	2	1		Low
Disrupt the breeding cycle of a population	2	2		Low
Modify, destroy, remove, isolate or decrease the availability or quality of	2	1		Low

Significant impact criteria	Likelihood	Consequence	Minimising, mitigation and management actions	Residual risk
habitat to the extent that the species is likely to decline			- As part of BMP incorporate a monitoring program for Black-footed Rock-wallaby using the recent July 2015 survey as baseline data (see Section 10.5.2) to monitor possible impacts of fire (would include naturally occurring fire in addition).	
Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat				
Introduce disease that may cause the species to decline				
Interfere with the recovery of the species	2	1		Low

Table 10-19 Risk assessment of the potential impact of unplanned wildfire on the borefield species

Significant impact criteria	Likelihood	Consequence	Minimising, mitigation and management actions	Residual risk
Lead to a long-term decrease in the size of a population.	2	2	- A separate Bushfire Management Plan will be required to manage this risk; - Produce and apply dedicated BMP and ensure appropriate wildfire controls are in place in an attempt to minimize and mitigate the potential 'High' impacts on the Great Desert Skink population of the area; - As part of BMP incorporate a monitoring program for Great Desert Skink using the recent July 2015 survey as baseline data to monitor possible impacts of fire (would include naturally occurring fire in addition).	Low
Reduce the area of occupancy of an important population				
Fragment an existing important population into two or more populations				
Adversely affect habitat critical to the survival of a species	2	1		Low
Disrupt the breeding cycle of a population	2	2		Low
Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	2	1		Low
Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat				
Introduce disease that may cause the species to decline				
Interfere with the recovery of the species	2	1		Low

General mitigation measures

Minimising impacts on fauna from unplanned wildfire will involve:

- Planning of where high-risk activities can take place
- Maintenance of fire breaks around high-risk areas/activities
- Active fire management, and the use of cool-season control burns
- Development of a Fire Management Plan
- Erosion control in waterways, if fire should occur and kill vegetation that otherwise stabilises soil/sediments.

10.7.8 Introduction and/or spread of exotic plants and animals

Noxious weeds

The establishment or spread of weeds can alter the ecological balance of arid zone ecology. Weed dominated habitats are generally less favourable for fauna than weed-free habitats. In particular, Buffel Grass (*Cenchrus ciliaris*) is a serious ecological pest in central Australia and its spread into rocky habitats of the study area should be prevented.

Transport of materials, vehicle movements and inappropriate waste management allows for introduction of new weeds and spread of existing weeds during construction and operations. These can cause:

- Local decline in habitat quality
- Displacement of fauna from habitats as habitat quality deteriorates
- Invasion of fauna species that are attracted to the weed species (e.g., cattle with buffel grass)
- Impacts on conservation significant fauna (i.e., threatened species)
- Changes in fuel load, resulting in changes to fire frequency and intensity.

Non-native animals

Creation of new roads and tracks and inappropriate management of waste (garbage) allows for introduction or spread of pest animal species (and potentially in some cases native predators including the dingo). This can cause:

- Increased predation pressure (particularly on threatened species) by opening up of new areas to feral predators (e.g., Cat, Red Fox) and potentially native predators such as the dingo
- Increased competition (particularly on threatened species) by natural areas becoming invaded by aggressive and dominating pest species (e.g., House Mouse, Black Rat)
- Large-scale decline in habitat quality as natural areas are trampled and grazed increasingly by non-native species that have the potential to alter ecological processes (e.g., Cattle, Camel, Goat).

Feral (and native – e.g. dingo) predators appear to be common within the study area, with all transects walked in the borefield (approx. 36 km walked by a minimum of three people situated at least 5 m apart) recording a least one of fox, cat or dingo. Each of these species was also recorded on the mine site. It will be important that with an increase in people on-site waste products are contained within a predator-proof fence to prevent access (access to easily obtained food resources could allow predators to increase in abundance).

The overall risk of the potential impact has been assessed against the significant impact criteria in Table 10-20 and Table 10-21.

Table 10-20 Risk assessment of the potential impact of exotic species on the Black-footed Rock-wallaby

Significant impact criteria	Likelihood	Consequence	Minimising, mitigation and management actions	Residual risk
Lead to a long-term decrease in the size of a population.	2	2	- Various design aspects will need to be considered for the mine such as a predator-proof compound to contain food waste; - Produce and apply dedicated BMP and ensure appropriate controls are in place to minimize and mitigate the potential 'High' impacts of exotic plants and animals on the Black-footed Rock-wallaby population of the area; - As part of BMP incorporate a monitoring program for Black-footed Rock-wallaby to monitor possible impacts of exotic plants and animals on the population. Part of this monitoring would include an assessment of the abundance of exotic/native predators.	Low
Reduce the area of occupancy of an important population				
Fragment an existing important population into two or more populations				
Adversely affect habitat critical to the survival of a species	2	1		Low
Disrupt the breeding cycle of a population	2	2		Low
Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	2	1		Low
Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat				
Introduce disease that may cause the species to decline				
Interfere with the recovery of the species	2	1		Low

Table 10-21 Risk assessment of the potential impact of exotic species on the borefield species

Significant impact criteria	Likelihood	Consequence	Minimising, mitigation and management actions	Residual risk
Lead to a long-term decrease in the size of a population.	2	2	- Various design aspects will need to be considered for the mine such as a predator-proof compound to contain food waste; - Produce and apply dedicated BMP and ensure appropriate	Low
Reduce the area of occupancy of an important population				
Fragment an existing important population into two or more populations				

Significant impact criteria	Likelihood	Consequence	Minimising, mitigation and management actions	Residual risk
Adversely affect habitat critical to the survival of a species	2	1	controls are in place to minimize and mitigate the potential 'High' impacts of exotic plants and animals on the Great Desert Skink and other potential threatened species populations of the area; - As part of BMP incorporate a monitoring program for Great Desert Skink to monitor possible impacts of exotic plants and animals on the population. Part of this monitoring would include an assessment of the abundance of exotic/native predators.	Low
Disrupt the breeding cycle of a population	2	2		Low
Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	2	1		Low
Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat				
Introduce disease that may cause the species to decline				
Interfere with the recovery of the species	2	1		Low

General mitigation measures

Minimising impacts on fauna from the introduction or spread of weeds will involve:

- Development of a Weed Management Plan (likely to be part of broader Biodiversity Management Plan) to document mitigation measures to control existing exotic plants, and to stem the spread of others
- Cleaning vehicles (washdown) that are new to the site, to prevent the introduction of new weeds
- Washdown when moving from areas of high weed density to areas that are currently weed free
- Keeping vehicles to established tracks and roads, and limiting the use of vehicles off-road
- Annual weed monitoring and mapping
- Weed control activities in consultation/partnership with Aileron and Napperby station owners as necessary.

Minimising impacts on native fauna from the introduction or spread of non-native fauna (and in some cases native predators such as dingoes) will involve:

- Sound waste management (garbage) to limit invasion/colonisation by Black Rat (*Rattus rattus*). This will also be particularly important for the Black-footed Rock-wallaby population near the mine site as any on-site garbage waste will need to be held in a securely fenced (i.e. the fence will need to prevent the entry of cats, foxes and dingoes) compound to prevent the scavenging of waste material and potential population increases in both feral and native predators
- A Pest Animal Management Plan will need to be produced (as part of a broader Biodiversity Management Plan)

- Investigate innovative new passive baiting and trapping methods
- Pest eradication/control program, targeting foxes, cats and rabbits across the study area, and non-native rats and mice in mine site and accommodation village areas
- Monitoring of feral fauna species.

10.7.9 Radioactivity

Arafura has determined the radiological risks to flora and fauna using the internationally recognised ERICA assessment method. The assessment demonstrated that the radiological risks to species of flora and fauna are negligible. See Chapter 12 for more detail.

10.7.10 Poisoning of fauna from drinking contaminated water

The links between use of tailings dams and poisoning in waterfowl and other species of avifauna is well documented in the Australian literature (Ryan and Shanks 1996).

Effects can be immediate or cumulative. Consumption of contaminated water can cause:

- Death or harm
- Disruption to breeding success
- Knock-on effects, by attracting predators/scavengers to ill/dead fauna.

The Nolans Project TSF/RSFs will be quite small (approx. 244.03 ha) and will likely contain free-standing supernatant water. It is unlikely that the EPBC listed threatened species that are known or have the potential to occur with the study area (Black-footed Rock-wallaby, Great Desert Skink, Greater Bilby, Princess Parrot) would access liquid contained within these facilities. There would be an extremely low chance that passing Princess Parrots would stop for a drink at a tailings dam.

The overall risk of the potential impact has been assessed against the significant impact criteria in Table 10-22 and Table 10-23.

Table 10-22 Risk assessment of the potential impact of waste water on the Black-footed Rock-wallaby

Significant impact criteria	Likelihood	Consequence	Minimising, mitigation and management actions	Residual risk
Lead to a long-term decrease in the size of a population.	1	1	- Avoid the possibility by maintaining WADCN levels below levels poisonous to wildlife, and prevent wildlife access to new tailings dams - Produce and apply a Water Quality Monitoring and Management Plan. A Tailings Dam	Low
Reduce the area of occupancy of an important population	1	1		Low
Fragment an existing important population into two or more populations	1	1		Low
Adversely affect habitat critical to the survival of a species	-	-		NA
Disrupt the breeding cycle of a population	-	-		NA

Significant impact criteria	Likelihood	Consequence	Minimising, mitigation and management actions	Residual risk
Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	-	-	Wildlife Monitoring Program would be incorporated into a BMP and would be more broadly directed at fauna in general rather than rock-wallabies.	NA
Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat	-	-		NA
Introduce disease that may cause the species to decline	-	-		NA
Interfere with the recovery of the species	-	-		NA

Table 10-23 Risk assessment of the potential impact of waste water on the borefield species

Significant impact criteria	Likelihood	Consequence	Minimising, mitigation and management actions	Residual risk
Lead to a long-term decrease in the size of a population.	1	1	- Avoid the possibility by maintaining WADCN levels below levels poisonous to wildlife, and prevent wildlife access to new tailings dams - Produce and apply a Water Quality Monitoring and Management Plan. A Tailings Dam Wildlife Monitoring Program would be incorporated into a BMP and would be more broadly directed at fauna in general rather than just specifically threatened species.	Low
Reduce the area of occupancy of an important population	1	1		Low
Fragment an existing important population into two or more populations	1	1		Low
Adversely affect habitat critical to the survival of a species	-	-		NA
Disrupt the breeding cycle of a population	-	-		NA
Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	-	-		NA
Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat	-	-		NA
Introduce disease that may cause the species to decline	-	-		NA
Interfere with the recovery of the species	-	-		NA

General mitigation measures

Impacts on native fauna from waste water can be reduced by:

- The reduction of impacts of TSF/RSFs on wildlife by following best practice guidelines currently recommended for the Northern Territory where practicable;
- The reduction of the attractiveness of the dam landscape for wildlife via design that includes, but is not limited to, the reduction of the dam surface area, removing dam bank vegetation, creating steep dam walls, providing alternative adjacent 'fauna friendly' water sources, and avoiding the creation of islands in the dam
- Looking into, where necessary, implementing appropriate bird-deterrent methods to keep waterbirds and birds of prey away.

10.7.11 Lowering or contamination of the water table

Changes to the water table can lead to changes in surface vegetation and habitat characteristics, particularly those communities reliant on surface water runoff and groundwater (e.g. riparian vegetation). Lowering or contamination of the water table has the potential to cause the following indirect impacts on fauna:

- Decline in availability of water resulting in loss of habitat for species relying on riparian habitat
- Shorter inundation period in waterbodies that may provide water for fauna.

After decommissioning, the mine void may act as a sink concentrating salts/contaminants which can seep to groundwater. This in turn can lead to:

- Impacts on vegetation that rely on groundwater or surface water flows, in turn leading to reduction in available habitat for fauna
- Unnatural inundation of fauna habitats.

In this Project, the water table (and therefore indirectly, fauna habitat) could be impacted by:

- Progressive water table drawdown from unsustainable groundwater extraction rates from the Southern basins borefield
- Mine void results in a long-term source of contaminated water with the potential to contaminate groundwater and surface water
- Embankment failure or overtopping of the TSF at the mine site and RSFs at the processing site, due to slope instability or extreme wet weather event (all of which could damage fauna habitat)
- Inappropriate storage and handling of hazardous substances on mine site or processing site resulting in uncontrolled release, spills or passive discharge.

Given the distance from these potential impacts and lack of reliance on Groundwater Dependent Ecosystems, none of the EPBC listed threatened species known or predicted to occur within the study area (Black-footed Rock-wallaby, Great Desert Skink, Greater Bilby, and Princess Parrot) are likely to be directly impacted by water table impacts. Residual and 'knock on' impacts could occur however, such as the very low chance that any of these species could consume contaminated water.

The overall risk of the potential impact has been assessed against the significant impact criteria in Table 10-24 and Table 10-25.

Table 10-24 Risk assessment of the potential impact of lowering or contamination of the water table on the Black-footed Rock-wallaby

Significant impact criteria	Likelihood	Consequence	Minimising, mitigation and management actions	Residual risk
Lead to a long-term decrease in the size of a population.	1	1	- Adherence and implementation of the mitigation measures outlined in below	Low
Reduce the area of occupancy of an important population	1	1		Low
Fragment an existing important population into two or more populations	1	1		Low
Adversely affect habitat critical to the survival of a species	-	-		NA
Disrupt the breeding cycle of a population	-	-		NA
Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	-	-		NA
Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat	-	-		NA
Introduce disease that may cause the species to decline	-	-		NA
Interfere with the recovery of the species	-	-		NA

Table 10-25 Risk assessment of the potential impact of lowering or contamination of the water table on the borefield species

Significant impact criteria	Likelihood	Consequence	Minimising, mitigation and management actions	Residual risk
Lead to a long-term decrease in the size of a population.	1	1	- Adherence and implementation of the mitigation measures outlined in below	Low
Reduce the area of occupancy of an important population	1	1		Low
Fragment an existing important population into two or more populations	1	1		Low
Adversely affect habitat critical to the survival of a species	-	-		NA

Significant impact criteria	Likelihood	Consequence	Minimising, mitigation and management actions	Residual risk
Disrupt the breeding cycle of a population	-	-		NA
Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	-	-		NA
Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat	-	-		NA
Introduce disease that may cause the species to decline	-	-		NA
Interfere with the recovery of the species	-	-		NA

General mitigation measures

Impacts on native fauna through changes to the water table can be reduced by:

- Constructing adequate bunds around the TSF/RSFs and other sources of potential contamination, to contain contaminated water in the event of heavy rainfall
- Monitor hydrogeological changes
- Undertake predictive groundwater flow modelling
- Development and implementation of groundwater and surface water management strategies
- Establish a Surface Water Plan for contaminated sites that serves to minimise the chance of contamination escaping into waterways.

10.7.12 Injury and death from collisions with vehicles

Creation and use of new roads and tracks through fauna habitats can lead to increased collisions with fauna, particularly at night, when nocturnal fauna can become dazed by a vehicle's bright lights. There can be both biotic and abiotic effects of roads on ecosystems (Coffin 2007) and these include:

- Injuring/killing fauna
- Breeding failure caused by loss of naïve young fauna, or adult fauna that have dependent offspring
- Changes to hydrology and water quality, both increases and decreases (Forman and Alexander 1998)
- Erosion and sediment transport (Jones et al. 2000)
- The introduction of chemical pollutants, including toxic contaminants (Forman 2003)
- Noise effects (Bayne et al. 2008)
- Direct mortality (Erritzoe et al. 2003)

- Barriers to movement (Shepard et al. 2008)
- The creation of new habitat types, especially in agricultural landscapes (Bellamy et al. 2000)
- The creation of corridors and conduits of species movement or invasion (von der Lippe and Kowarik 2008)
- Fragmentation and edge effects (Hawbaker et al. 2006).

It is possible that several of the species that occur within the borefield could occasionally be struck and killed by vehicles moving in the area (e.g. Great Desert Skink).

The majority of the threatened species that are known or have the potential to occur in the study area are nocturnal and would only be affected by vehicles travelling at night.

The overall risk of the potential impact has been assessed against the significant impact criteria in Table 10-26 and Table 10-27 below.

Table 10-26 Risk assessment of the potential impact of traffic mortality on the Black-footed Rock-wallaby

Significant impact criteria	Likelihood	Consequence	Minimising, mitigation and management actions	Residual risk
Lead to a long-term decrease in the size of a population.	1	1	- Produce and apply a Traffic and Road Safety Management Plan, a Weed Hygiene Procedure and provision of on-site wash down facilities. Aspects of these will be incorporated into a BMP. - Implementation of speed limits and possibly the reduction in vehicle travel at night.	Low
Reduce the area of occupancy of an important population	1	1		Low
Fragment an existing important population into two or more populations	1	1		Low
Adversely affect habitat critical to the survival of a species	-	-		NA
Disrupt the breeding cycle of a population	-	-		NA
Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	-	-		NA
Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat	-	-		NA
Introduce disease that may cause the species to decline	-	-		NA
Interfere with the recovery of the species	-	-		NA

Table 10-27 Risk assessment of the potential impact of traffic mortality of the water table on the borefield species

<table>
<tr><th>Significant impact criteria</th><th>Likelihood</th><th>Consequence</th><th>Minimising, mitigation and management actions</th><th>Residual risk</th></tr>
<tr><td>Lead to a long-term decrease in the size of a population.</td><td>3</td><td>2</td><td rowspan="9">- Produce and apply a Traffic and Road Safety Management Plan, a Weed Hygiene Procedure and provision of on-site wash down facilities. Aspects of these will be incorporated into a BMP.
- Implementation of speed limits and possibly the reduction in vehicle travel at night.</td><td>Low</td></tr>
<tr><td>Reduce the area of occupancy of an important population</td><td>3</td><td>2</td><td>Low</td></tr>
<tr><td>Fragment an existing important population into two or more populations</td><td>3</td><td>2</td><td>Low</td></tr>
<tr><td>Adversely affect habitat critical to the survival of a species</td><td>-</td><td>-</td><td>NA</td></tr>
<tr><td>Disrupt the breeding cycle of a population</td><td>3</td><td>2</td><td>Low</td></tr>
<tr><td>Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline</td><td>3</td><td>2</td><td>Low</td></tr>
<tr><td>Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat</td><td>-</td><td>-</td><td>NA</td></tr>
<tr><td>Introduce disease that may cause the species to decline</td><td>-</td><td>-</td><td>NA</td></tr>
<tr><td>Interfere with the recovery of the species</td><td>-</td><td>-</td><td>NA</td></tr>
</table>

General mitigation measures

To minimise and mitigate the effects of increased road traffic or increased road network on the threatened species populations the following actions are recommended:

- Keep the proposed road network to a minimum and upgrade and utilise existing vehicle tracks
- Reduce speed limits and install speed reduction infrastructure such as whoa-boys and speed humps
- Provide road safety and awareness training to all staff and contractors with respect to safe driving in areas where native wildlife occurs
- Implementing and enforcing speed restrictions in high-use areas
- Limiting the movement of vehicles at night (between the period of one hour before dusk to one hour after dawn)
- Monitoring roadkill for threatened species
- Documenting location and time of day of roadkill within the study area, to determine high-risk periods or locations (additional mitigation may be required)

- Fatigue management for vehicle operators
- Development and implementation of a Traffic Management Plan.

10.8 Summary of impacts for threatened fauna

10.8.1 Black-footed Rock-wallaby – MacDonnell Ranges Race (Vulnerable)

Population in the study area

Black-footed Rock-wallaby is known to occur throughout the rocky habitats of the eastern parts of the Reynolds Range which incorporates the study area. Transient populations only appear to occur within the actual mine site footprint, however a breeding population was found to occur in the immediate vicinity of the mine site.

Impacts

Clearing

The habitat to be lost within the project footprint appears to be foraging/dispersal habitat only compared to the foraging/breeding/dispersal habitat within the surrounding Reynolds Range within 2km of the proposed mine. Clearing of low quality habitat was rated as having an initial low risk to the rock-wallaby population that exists in the vicinity of the mine. For example, it is unlikely that the clearing and operation of the mine would lead to the fragmentation of the rock-wallaby population in the area as suitable habitat (foraging, breeding, shelter) will continue to persist in the rocky areas surrounding the mine site. Suitable habitat surrounds the mine site and exists on all sides of the proposal.

Dust

Populations of Black-footed Rock-wallaby occur within <2 km of the mine site and could be subjected to low levels of dust. Mitigation measures will need to be implemented to keep dust levels to a minimum, however it is unlikely that dust levels following mitigation would penetrate into surrounding rocky habitats in excess of 2km from the mine site to the extent that a significant impact would be expected on the rock-wallaby population. Dust was rated as having an initial low impact on the rock-wallaby population of the study area.

Noise

The Black-footed Rock-wallaby occurs within <2 km of the mine site and occasionally uses habitats within the mine site. It is possible that noise generated by the mine could minimise rock-wallaby movements through the mine site, however particularly noisy activities would likely occur during diurnal periods when rock-wallabies are sheltering and noise may be somewhat buffered by their rocky, elevated habitat. It will be necessary to restrict particularly loud activities (e.g. blasting) from occurring during rock-wallaby nocturnal activity period when they could potentially be disturbed. This will form part of the noise mitigation strategy. Noise was rated as having an initial low risk to the rock-wallaby population of the study area.

Light

As mentioned above, the Black-footed Rock-wallaby occurs within the rocky habitats that surround the mine site and also occasionally use the habitats of the mine site itself. It is possible that light emitted from the mine site could adversely impact on nocturnal movements of rock-wallabies in the immediate vicinity of the mine site. Rock-wallabies occurring at distances greater than or equal to 2 km from the mine site are unlikely to be adversely impacted by artificial lighting, provided that lights are not directed at their habitat. The distance and buffering by the elevation and rocky habitat may diminish the penetration of light used for illumination purposes. Light was rated as a low initial impact for the rock-wallaby population of the study area, with the mitigation measures recommended it is expected to remain a very low risk.

Wildfire

Wildfire within Black-footed Rock-wallaby habitat is a major impact on populations as it burns food plants such as Spearbush and fig rendering habitats unsuitable for periods of time. Extensive burning of Black-footed Rock-wallaby habitat could be detrimental to populations as the fire would remove important shelter and food resources. Wildfire was rated initially as a high risk to the rock-wallaby populations of the study area.

Continued persistence of the Black-footed Rock-wallaby in the area will depend on prevention of wildfire in the surrounding rocky habitats of the study area and surrounds. Rock-wallabies were not found within the study area where previous fire had occurred.

Implementing mitigation measures such as fire management plan would reduce the risk to medium, however this risk will require the most intensive management.

Introduction and/or spread of exotic plants and animals

The potential for exotic plants and animals as well as some native predators to increase in abundance due to the proposal is possible. The increase in food waste products has the potential to be used as a food resource by feral predators (fox, cat) and native predators (dingo), which in turn could lead to increases in the populations of these species. Increases in predator abundance could result in increased predation on threatened species such as the Black-footed Rock-wallaby. It will be an important mitigation measure that on-site waste products are contained within a predator-proof fence to prevent access. The impact of predators only increases when combined with wildfire as this removes important refuge allowing predators easier access to prey.

There is also potential for exotic plants such as Buffel Grass to increase in abundance as a result of seed brought into the site on vehicle tyres and other equipment. Buffel Grass is known to be flammable and has the ability to allow a fire to carry through rocky habitats. This could be a high risk for rock-wallaby habitats, opening them up to wildfire. Mitigation for exotic plants is likely to include vehicle hygiene protocols and monitoring for an increase in the incidence of Buffel Grass.

The spread of exotic plants and animals was rated as an initial high risk prior to mitigation. With mitigation it is possible that the risk posed by these threats can be managed down to a low risk.

Poisoning of fauna from drinking contaminated water

It is unlikely that Black-footed Rock-wallaby would access liquid contained within a tailings dam due to the location of such facilities away from their preferred rocky habitats. Tailings facilities proposed for this project occur predominantly within mulga woodland – it would highly unlikely for rock-wallabies to use this habitat. This rated as a low initial risk.

Lowering or contamination of the water table

Impacts to the water table have the potential to impact on Groundwater Dependent Ecosystems (GDEs) such as riparian River Red Gum communities. No GDEs occur within rock-wallaby habitats, therefore water table impacts to rock-wallaby are likely to be very low. This rated as a low initial risk.

Injury and death from collision with vehicles

The Black-footed Rock-wallaby is primarily nocturnal and would only be affected by vehicles travelling at night. There would be an extremely low likelihood that rock-wallabies would decend from rocky habitats and cross the road in the vicinity of the mine site. On the vary rare occasion that wallabies decend to flat ground to disperse, mitigation measures would be put in place to minimise the chance of a collision (which would be extremely low as the chance of encountering a rock-wallaby outside of rocky habitats would be very low). Mitigation would likely involve the implementation of speed limits and possibly a reduction in vehicle travel at night.

The initial risk rating that death from vehicle collision for the rock-wallaby population was low.

Highest risk sources of impact for the Black-footed Rock-wallaby

Potential impacts that pose the highest risk to the Black-footed Rock-wallaby are:

- Impacts of unplanned wildfire;
- Impacts associated with introduction and/or spread of exotic plants and animals, particularly predators.

10.8.2 Greater Bilby (Vulnerable)

Population in the study area

The Greater Bilby was not recorded during any of the previous surveys within the study area (including aerial flyover of habitat looking for burrows). Despite not being detected, this species is mobile and could still occur in very low abundance (thus difficult to detect). Impacts would likely be low with the primary impacts being vehicle strike at night (low likelihood) and increased predation due to greater presence of people and their food waste (leading to increase in predator abundance).

Impacts

Clearing

The small amount of clearing that will occur within potential Greater Bilby habitat is unlikely to have an impact on a population should it exist given the large area of similar habitat in the region (well in excess of 40,000 ha). Clearing of low quality habitat was rated as having an initial low risk to a Greater Bilby population should it exist.

Dust

A population of Greater Bilby either does not or would not regularly occur in the vicinity of the mine site (Greater Bilby populations would most likely occur in habitats >10km from the mine site) and hence would only ever be subjected to very low dust levels mainly from vehicles driving along gravel/dirt tracks. Dust was rated as having an initial low risk to a Greater Bilby population should it exist.

Noise

A population of Greater Bilby either does not or would not regularly occur in the vicinity of the mine site (Greater Bilby populations would most likely occur in habitats >10km from the mine site) and hence would only ever be subjected to very low noise levels mainly from vehicles driving along gravel/dirt tracks. Noise was rated as having an initial low risk to a Greater Bilby population should it exist.

Light

A population of Greater Bilby either does not or would not regularly occur in the vicinity of the mine site (Greater Bilby populations would most likely occur in habitats >10km from the mine site) and hence would only ever be subjected to very low light levels mainly from vehicles driving along gravel/dirt tracks. Light was rated as having an initial low risk to a Greater Bilby population should it exist.

Wildfire

Controlled and strategic cool patch burns of spinifex sandplain habitat could have positive outcomes for species such as Greater Bilby (promotes food plants). Extensive burns (not patchy) would however be detrimental as the fire would remove shelter and open up bilbies to predation by exotic and native predators.

Implementing mitigation measures such as fire management plan would reduce the risk from high to medium, however this risk will require the most intensive management.

Introduction and/or spread of exotic plants and animals

The possible increase of exotic and native predators in response to food waste from the mine could have a high impact on a Greater Bilby population should it occur, especially if combined with wildfire.

Poisoning of fauna from drinking contaminated water

It is unlikely that Greater Bilby would access liquid contained within a tailings dam due to the location of such facilities away from their preferred sandplain habitats. Tailings facilities proposed for this project occur predominantly within mulga woodland – it would unlikely that Greater Bilby would occupy the location for the tailings dam/s. This rated as a low initial risk.

Lowering or contamination of the water table

Impacts to the water table have the potential to impact on Groundwater Dependent Ecosystems (GDEs) such as riparian River Red Gum communities. No GDEs occur within Greater Bilby habitats, therefore water table impacts to Greater Bilby are likely to be very low. This rated as a low initial risk.

Injury and death from collision with vehicles

It is possible that Greater Bilby, should they be present within the borefield could occasionally be struck and killed by vehicles moving in the area (there is a very low likelihood for this to occur). Given the Greater Bilby is primarily nocturnal, it would only be affected by vehicles travelling at night. Mitigation would likely involve the implementation of speed limits and possibly the reduction in vehicle travel at night.

The initial risk rating that death from vehicle collision for the Greater Bilby population was medium, with control in place this would be reduced to low.

Highest risk sources of impact for the Greater Bilby

Potential impacts that pose the highest risk to the Greater Bilby are:

- Impacts of unplanned wildfire;
- Impacts associated with introduction and/or spread of exotic plants and animals, particularly predators;
- Injury and death from collision with vehicles.

10.8.3 Great Desert Skink (Vulnerable)

Population in the study area

The Great Desert Skink was only recorded on one occasion in the far south-west of the proposed borefield. Although only one active Great Desert Skink warren was recorded despite extensive searches of the proposed borefield it is possible that this species could occur within any of the sandplain habitats of the study area. A single Great Desert Skink active warren was recorded in the far south-west of the study area that is currently situated outside of the proposed development area for the borefield. It will be important to avoid this location during the construction and operation of the project. Although only the one active warren was observed, several animals of different sizes were recorded using the warren on motion sensing cameras.

Impacts

Clearing

The small amount of clearing that will occur within potential Great Desert Skink habitat is unlikely to have an impact on a population should it exist given the large area of similar habitat in the region (well in excess of 40,000 ha). Clearing of low quality habitat was rated as having an initial low risk to the Great Desert Skink population.

Dust

A population of Great Desert Skink either does not or would not regularly occur in the vicinity of the mine site (Greater Desert Skink populations would most likely occur in habitats >10km from the mine site) and hence would only ever be subjected to very low dust levels mainly from vehicles driving along gravel/dirt tracks. Dust was rated as having an initial low risk to the Great Desert Skink population.

Noise

A population of Great Desert Skink either does not or would not regularly occur in the vicinity of the mine site (Great Desert Skink populations would most likely occur in habitats >10km from the mine site) and hence would only ever be subjected to very low noise levels mainly from vehicles driving along gravel/dirt tracks. Noise was rated as having an initial low risk to the Great Desert Skink population.

Light

A population of Great Desert Skink either does not or would not regularly occur in the vicinity of the mine site (Great Desert Skink populations would most likely occur in habitats >10km from the mine site) and hence would only ever be subjected to very low light levels mainly from vehicles driving along gravel/dirt tracks. Light was rated as having an initial low risk to the Great Desert Skink population.

Wildfire

Large-scale, intense wildfires from a lack of patch burning can devastate or fragment local populations of Great Desert Skink (Woinarski *et. al.* 2007). Extensive burns (not patchy) of Great Desert Skink habitat could be detrimental as the fire would remove important shelter and food resources.

Implementing mitigation measures such as fire management plan would reduce the risk from high to medium, however this risk will require the most intensive management as this risk is potentially the greatest to this species especially when combined with an increase in exotic and native predators.

Introduction and/or spread of exotic plants and animals

The possible increase of exotic and native predators in response to food waste from the mine could have a high impact on the Great Desert Skink population, especially if combined with wildfire.

Poisoning of fauna from drinking contaminated water

It is unlikely that Great Desert Skink would access liquid contained within a tailings dam due to the location of such facilities away from their preferred sandplain habitats. Tailings facilities proposed for this project occur predominantly within mulga woodland – it would highly unlikely that Great Desert Skink would occupy the location for the tailings dam/s or regularly access standing water. This rated as a low initial risk.

Lowering or contamination of the water table

Impacts to the water table have the potential to impact on Groundwater Dependent Ecosystems (GDEs) such as riparian River Red Gum communities. No GDEs occur within Great Desert Skink habitats, therefore water table impacts to Great Desert Skink are likely to be very low. This rated as a low initial risk.

Injury and death from collision with vehicles

It is possible that Great Desert Skink could occasionally be struck and killed by vehicles moving in the area (there is a very low likelihood for this to occur). Given the Great Desert Skink is primarily nocturnal, it would only be affected by vehicles travelling at night. Mitigation would likely involve the implementation of speed limits and possibly the reduction in vehicle travel at night.

The initial risk rating that death from vehicle collision for the Great Desert Skink population was medium, with control in place this would be reduced to low.

Highest risk sources of impact for the Great Desert Skink

Potential impacts that pose the highest risk to the Great Desert Skink are:

- Impacts of unplanned wildfire;
- Impacts associated with introduction and/or spread of exotic plants and animals, particularly predators;
- Injury and death from collision with vehicles.

10.8.4 Princess Parrot (Vulnerable)

Population in the study area

The Princess Parrot was not recorded during the previous surveys and there are no historic records within the proposed project footprint, however it is possible that this species could occur within any of the habitats within the proposed project footprint apart from the rocky habitats. However, there are many thousands of hecatres of similar habitat in the region that this species could also use.

This species is highly nomadic and irruptive in response to rainfall and improved conditions. This species arrived at Newhaven Station in 2012 (approx. 180 km from the Nolans study area) following good rainfall in central Australia. It is possible that this species could visit the study area under similar conditions in the future.

Impacts

Clearing

The small amount of clearing that will occur within potential Princess Parrot habitat is unlikely to have an impact on a population should it exist given the large area of similar habitat in the region (well in excess of 40,000 ha). Clearing of low quality habitat was rated as having an initial low risk to the Princess Parrot population.

Dust

A population of Princess Parrot either does not or would not regularly occur in the vicinity of the mine site (Princess Parrot populations would most likely occur in habitats >10km from the mine site) and hence would only ever be subjected to very low dust levels mainly from vehicles driving along gravel/dirt tracks. Dust was rated as having an initial low risk to a potential Princess Parrot population.

Noise

A population of Princess Parrot either does not or would not regularly occur in the vicinity of the mine site (Princess Parrot populations would most likely occur in habitats >10km from the mine site) and hence would only ever be subjected to very low noise levels mainly from vehicles driving along gravel/dirt tracks. Noise was rated as having an initial low risk to a potential Princess Parrot population.

Light

A population of Princess Parrot either does not or would not regularly occur in the vicinity of the mine site (Princes Parrot populations would most likely occur in habitats >10km from the mine site) and hence would only ever be subjected to very low light levels mainly from vehicles driving along gravel/dirt tracks. Light was rated as having an initial low risk to potential Princess Parrot populations.

Wildfire

It is more difficult to determine the impacts of wildfire on a nomadic and highly mobile species such as the Princess Parrot. It is possibly safe to assume that various food plants and certainly hollow-bearing nest trees could be destroyed by fire.

Implementing mitigation measures such as fire management plan would reduce the risk from high to medium.

Introduction and/or spread of exotic plants and animals

The possible increase of exotic and native predators in response to food waste from the mine could have an adverse impact on the Princess Parrot, particularly as feral cats would likely prey on this species given the chance.

Poisoning of fauna from drinking contaminated water

There would be an extremely low chance that passing Princess Parrots would stop for a drink at a tailings dam and therefore be at risk of poisoning from such as facility. It is likely that this would be a low risk even before mitigation due the rare chance that Princess Parrot would be present within the study area to begin with.

Lowering or contamination of the water table

Impacts to the water table have the potential to impact on Groundwater Dependent Ecosystems (GDEs) such as riparian River Red Gum communities. No GDEs occur within Princess Parrot habitats within the vicinity of the mine site, therefore water table impacts to Princess Parrot are likely to be very low. This rated as a low initial risk.

Injury and death from collision with vehicles

It is possible that Princess Parrot could very occasionally be struck and killed by vehicles moving in the project footprint (there is an extremely low likelihood for this to occur however as this species would be rare at best within the study area to begin with). Mitigation would likely involve the implementation of speed limits and possibly the reduction in vehicle travel at night.

The initial risk rating that death from vehicle collision for the Princess Parrot population was low.

Highest risk sources of impact for the Princess Parrot

Potential impacts that pose the highest risk to the Princess Parrot are:

- Impacts of unplanned wildfire;
- Impacts associated with introduction and/or spread of exotic plants and animals, particularly predators;
- Injury and death from collision with vehicles.

10.9 Mitigation and monitoring

Based on the identified sources of impact, the following mitigation measures are recommended below to reduce the level of impact to an acceptable level.

10.9.1 Mitigation

Source of impact	Mitigation Measure	Species
General		
	Site induction will include the following components for biodiversity management: • Summary of biodiversity at the Project including ecologically sensitive areas and threatened fauna; • Identification of potential impacts to biodiversity from the Project activities; • Requirement to enter and exit site through recognised vehicle access points, and to travel around site using existing/approved roads and tracks only; • Requirement for speed restrictions across the Project; and No work to be undertaken without an approved Ground Disturbance Permit.	All species
	No work undertaken within 200 m of the Great Desert Skink warren recorded within the Borefield.	Great Desert Skink
	Implement all aspects of the Environmental Management Plan including the following sub-plans: • Air and Dust Management Plan; • Erosion and Sediment Control Plan; • Fire Management Plan; • Weed Management Plan; • Mine Closure Plan; and • Non-mineralised Waste Management Plan.	All species

Source of impact	Mitigation Measure	Species
	Seal/cover open holes, pits, trenches (e.g. monitoring bores, production wells, exploration bores) when not manned to prevent ground-dwelling fauna from falling in.	All species
Clearing of vegetation		
	• Use previously disturbed areas before clearing vegetation from undisturbed areas. • Minimise ground disturbance at all locations and specifically at/near riparian zones. • Maximum clearing easements for haul roads and access roads will be complied with. • Qualified ecologist will be present during clearing of the Borefield where the Great Desert Skink is known, to capture/translocate animals unable to escape. • Clearly mark areas of land to be cleared and areas to be retained (No-Go areas), so that impacts do not extend any further than necessary into important habitat. • If possible, plan to clear vegetation progressively and incrementally as needed, rather than through large-scale clearing in advance. • Rehabilitate/stabilise cleared land progressively as activities are completed (which forms part of the Closure and Rehabilitation Plan).	All species
	Consider applying a cool, well-managed fuel-reduction burn to all habitats to be cleared (but not beyond), to encourage fauna to flee prior to clearing. The specifics of fuel-reduction burns to be determined in consultation with relevant stakeholders prior to fire being lit.	All species
Noise		
	Where possible, high-impact noise (e.g. blasting) will be limited to daylight hours.	All species
Light		
	Implement a light reduction strategy during the detailed design phase including: • Limit artificial light to areas where it is essential; • Turn off lights when not required; • Avoid the flood of light into natural habitats and limit the escape of light into surrounding areas of fauna habitat (i.e. using shields/deflectors); • Ensure that artificial lighting is not directed upwards or laterally (i.e. should be directed towards the ground); • Use lower (i.e. closer to the ground) rather than higher lighting installations; • Use lower wavelengths of light wherever possible i.e. red/yellow lights; • Use light intensities that are as low as possible without reducing safety or efficiency; and • Avoid painting large structures bright or reflective colours and minimise use of bright or reflective construction materials and finishes for large structures.	All species

Source of impact	Mitigation Measure	Species
Unplanned wildfire		
	• Carefully plan and identify where high-risk activities can take place. • Maintain adequate fire breaks around high-risk areas/activities. • Implement active fire management, using localised cool-season control burns within 100 m of mine activities and roads to reduce fuel loads.	All species
Pest animals		
	As part of the Waste Management Plan, implement sound waste (garbage) management to limit invasion/colonisation by Black Rat (*Rattus rattus*).	All species
	General site wastes will be managed to prevent/reduce interaction with fauna. Waste management includes: • Regular burning of the landfill; • Fencing installed surrounding the landfill to restrict interaction with fauna; • Waste storage outside of the landfill is to be situated in bins with lids secured; • Waste oils and/or hazardous substances will be kept in sealed containers and/or covered; and All domestic waste outside the landfill/waste-storage facility is to be stored in vermin-proof bins with lids secured.	• Black-footed Rock-wallaby • Great Desert Skink • Greater Bilby
	Implement a Pest Monitoring Plan to monitor feral cat and fox populations to determine if control measures are required. The plan is summarised in Table 10-28.	All species
Surface and groundwater		
	• Reduce attractiveness (to wildlife) of the Residue Storage Facility, Flotation Tailings Storage Facility, Sediment Basins and Process Water Ponds through the implementation of Best Practice Guidelines for Reducing Impacts of Tailings Storage Facilities on Avian Wildlife (DME, 1998). • Fence off tailings storage facilities to prevent ground-based fauna from accessing the water.	Princess Parrot
Vehicle collision		

Source of impact	Mitigation Measure	Species
	• Keep the proposed road network to a minimum and upgrade and utilise existing vehicle tracks. Ensure that all vehicles travel on these designated roads, and not on secondary or short-cut roads/tracks. • Implement and enforce speed restriction controls for all roads across the entire study site. • Implement slower speed limitsfor all vehicles moving at night in sensitive habitat areas, to reduce the likelihood of roadkill. • Upgrade high-use areas to be safer for vehicles and fauna (e.g. no blind curves, wider shrub-free verges). • If injured fauna is encountered, assess the situation and potential requirement to euthanize and/or contact Wild Care Alice Springs for advice: M: +61 419 221 128 E: wildcareasp@gmail.com • If dead animals are found on/beside roads, the Environmental Officer is to be notified immediately to remove the carcass a minimum of 20 m into adjacent land.	

10.9.2 Monitoring

Monitoring plans have been established to determine if mitigation measures at the Project are sufficient. The plans include:

- Pest Monitoring Plan – Cats, Foxes and Dingoes (Table 10-28);
- Register – Cats, Foxes and Dingoes (Table 10-29);
- Pest Animal Management Plan (Table 10-30);

Threatened Species Monitoring – Black-footed Rock-wallaby

- Table 10-31); and
- Threatened species monitoring – Sandplain habitats (Table 10-32).

Table 10-28 Pest Monitoring Plan

Program		Pest Monitoring Plan – Cats, Foxes and Dingoes
Objective		Establish baseline and subsequent comparative data on population sizes of feral predators and dingoes to inform control program.
Survey Effort	**Survey**	Establish baseline data by undertaking a motion-sensing camera survey prior to construction, using site occupancy as the measure of predator populations. Cameras to be deployed for a minimum of 28 nights.
	Operation	Establish 30 baited camera stations that can be repeatedly used including: • 10 sites within 100 m of proposed mine activities (particularly around the landfill); • 10 sites approximately 1 km from mine activities; and • 10 sites more than 5 km from mine activities.
	Timing	Annual (during operation)
	Personnel	Qualified ecologists.

Trigger Points	**Cats / Foxes**	**Acceptable level of change:** No increase Any increase in population size is likely to be detrimental to biodiversity. Action required if >10% increase in numbers of individuals detected across two surveys.
	Dingoes	**Acceptable level of change:** Moderate change Dingoes are native predators and their presence is likely to limit the population size of other predators (cats and foxes). Therefore, dingo presence and increase in population is acceptable. However, over-abundance of dingoes is likely to be detrimental to threatened species. Action required if >50% increase in abundance across two surveys.
Contingency		Implement or increase predator control program as required. Increase cat/fox control efforts, through trapping, poisoning, shooting. Make sure predator control method does not result in the unintentional capture or death of threatened fauna species.

Table 10-29 Register

Program		Register – cats, foxes, rabbits and dingoes
Objective		Provide additional information on feral predator and pest animal populations, in conjunction with monitoring program.
Method	**Survey**	Predator and pest-animal sightings are to be recorded in the Fauna Sighting and fatality Register (Appendix A) to be established and maintained. Input will be opportunistic, however all personnel will be encouraged to report all sightings of cats (including colour and identifying markings, if possible), foxes, rabbits and dingoes.
	Timing	Continually.
	Personnel	All personnel.
Trigger Points	**Cats / Foxes / Rabbits**	**Acceptable level of change:** No increase *Any* increase in population size is likely to be detrimental to biodiversity. Additional mitigation action required if the Fauna Sighting and fatality Register (Appendix A) indicates an increase in sightings in a particular area (e.g. more often per week, larger numbers per night, more individuals in an area). Action required if >10% increase in numbers of individuals detected across a six month period.
	Dingoes	**Acceptable level of change:** n/a Fauna Sighting and fatality Register not to be used to guide response actions for dingoes.
Contingency		Implement or increase predator and pest-animal control program as required (e.g. if there is a notable increase in sightings of non-native predators in the study area). Increase cat/fox/rabbit control efforts, through trapping, poisoning, shooting, in consultation with DLRM and CLC. Make sure predator/pest control method does not result in the unintentional capture or death of threatened fauna species.

Table 10-30 Pest Animal Management Plan

Program		Pest Animal Management Plan (Bait and Trapping Plan)
Objective and approach		Implement a pest eradication/control program targeting foxes, cats and rabbits across the Project and non-native rats and mice at the mine site and accommodation village to minimise potential impacts of vermin and pest predators.
Target species		• Non-native rats/mice (e.g., *Rattus rattus*, *Mus musculus*); • European Rabbit; • Red Fox; • Feral Cat; and • Dingo (if overabundant).
Rats / Mice	**Methods**	Poisoned baits in and under buildings and within the confines (fences) of the landfill facility.
	Timing	All year.
	Location	Offices and accommodation areas across the Project and around the landfill facility.
Rabbits	**Methods**	Warren fumigation and/or ripping. Prior to control methods being used on a suspected rabbit warren, motion-sensing cameras must be deployed at warren entrances for at least 30 days during the warmer months (October to March) to make certain that the burrows aren't used by Great Desert Skinks, or any other threatened fauna species. If any burrow is found to support a native threatened species, then fumigation and warren ripping are not suitable. Other rabbit-control methods are to be established (e.g., trapping, shooting).
	Timing	All year, as required. The need for rabbit control will be informed by the Fauna Sighting and fatality Register (Appendix A), and the results of other fauna monitoring (e.g. use of motion-sensing cameras).
	Location	Across Study area, particularly in sandplain areas where the impact of rabbits on native threatened species has the potential to be greater.
Cats / Foxes	**Methods**	Range of methods to be trialled upon the outset of the Project to determine the most effective and efficient method. Possible methods include: • Poisoned baiting; • Trapping (e.g., cage trapping); • Shooting; and • Grooming traps (innovative new passive baiting and trapping methods that target cats (http://www.ecologicalhorizons.com/initiatives). Grooming Traps may provide a long-term tool to control trap- or bait-shy cats in areas of high conservation value (e.g. in areas of known Black-footed Rock-wallaby habitat).
	Timing	Annually, and more frequently if required on the basis of monitoring results.
	Location	Mine site and broader project area. Focus efforts initially in and around the mine site and landfill facility where non-native rats and mice are most expected to attract non-native predators. Expand area of control if any of the fauna monitoring or Fauna Sighting and fatality Register (Appendix A) data suggest that predator numbers have increased in areas away from the mine site.
Dingoes	**Methods**	Dingoes are native predators and are not expected to require regular or frequent active population control measures. However, if the mine activities promote an increase in non-native rats and mice, allowing dingo populations to get unnaturally large to the point where they threaten native fauna also, then control measures may be required. Possible methods include: • Poisoned baiting; or

		• Shooting. Control of dingo populations, if required, is expected to involve removal of relatively small numbers of individuals, rather than broadscale population control and would be undertaken in consultation with regulatory authorities.
	Timing	As needed, on the basis of monitoring results.
	Location	Across mine site and broader project area, as required.
Personnel		Environmental Officer
Contingency		Implement or increase predator and pest-animal control program as required. Make sure predator and pest-animal control method does not result in the unintentional capture or death of threatened fauna species.

Table 10-31 Threatened Species Monitoring – Black-footed Rock-wallaby

Program		Threatened Species Monitoring – Black-footed Rock-wallaby
Objective		Assess the potential impact from the Project on Black-footed Rock-wallaby through: • Documenting the persistence of the local rock-wallaby population; • Understanding changes in habitat use near the mine site; • Evaluating the effectiveness of predator control measures; and • Evaluating the effectiveness of vehicle movement restrictions.
Method	**Survey**	Aerial and motion camera surveys.
	Locations	Marginally rocky habitat, rocky outcrops near the mine site and in surrounding rocky areas (landscape context).
	Timing	Annual.
	Personnel	Qualified ecologist.
Trigger Points		**Acceptable level of change:** moderate change Additional mitigation action required if: • Rock-wallabies are not detected in rocky outcrop near the mine site and in the preceding year rock-wallabies are killed on the roads in the study area; • Predator monitoring shows that numbers of predators in the study area over the preceding 12 months increased (cat and fox) or increased greatly (dingo); or • Wildfire in rocky areas during the preceding 12 months and no rock-wallabies are detected in nearby rocky areas.
Contingency		Mitigation measures include: • Increase cat/fox control efforts (trapping, poisoning, shooting) if predator numbers have increased; • Broaden fire breaks in high risk areas to prevent future fires, if fire may have been responsible, and • Reduce vehicle speeds or access in high-risk areas if roadkill may have been the cause.

Table 10-32 Threatened Species Monitoring – Sandplain Habitats

Program	Threatened species monitoring – Sandplain Habitats
Objective	To document the persistence of known threatened species in the vicinity of the mine, and to evaluate the effectiveness of predator control measures.

Method	**Survey**	Motion-sensing camera surveys within known threatened species habitat for Great Desert Skink including two cameras at known warrens. Transect surveys searching for warrens within known threatened species habitat for Great Desert Skink. Camera surveys will comprise five 400m camera transects, each comprising 5 cameras at 100m intervals and be left insitu for 28 nights during Great Desert Skink active season.
	Locations	Sandplain Habitat.
	Timing	Annual.
	Personnel	Qualified ecologists.
Trigger Points		**Acceptable level of change:** small change Additional mitigation action required if: • >20% decrease in numbers of Great Desert Skink and in the preceding year an incident of roadkill is recorded; • Predator monitoring shows that numbers of predators in the study area over the preceding 12 months increased (cat and fox) or increased greatly (dingo); or • Wildfire in the sandplain habitat during the preceding 12 months and no Great Desert Skink are detected.
Contingency		Mitigation measures include: • Increase cat/fox control efforts (trapping, poisoning, shooting) if predator numbers have increased; • Broaden fire breaks in high risk areas to prevent future fires, if fire may have been responsible, and • Reduce vehicle speeds or access in high-risk areas if roadkill may have been the cause.

10.10 Conclusion

Across the 2010 and 2015 surveys, 174 native terrestrial fauna species were recorded, including 25 mammals, 103 birds, 41 reptiles, three frogs. Five introduced fauna species (all mammals) were recorded overall. Four threatened species that do occur or could occur within the study area are listed as Vulnerable under the EPBC Act and are the focus of this chapter:

- **Four mammals** –
  - Black-footed Rock-wallaby, *Petrogale lateralis MacDonnell Ranges race* (Vulnerable)
  - Greater Bilby, *Macrotis lagotis* (Vulnerable)
- **One bird** - Princess Parrot, *Polytelis alexandrae* (Vulnerable)
- **One reptile** - Great Desert Skink, *Liopholis kintorei* (Vulnerable).

To minimise or avoid significant impacts, mitigation measures will need to be implemented during all construction and operations activities in habitats that are most likely to support these species.

One of these species (Black-footed Rock-wallaby) is typically restricted to rocky habitats, which occur mainly in the mine site area and in isolated outcrops in the borefield area (e.g. Reaphook Hills).

Another species (Great Desert Skink) is restricted to sandy habitats, which occur throughout the borefield area and along the southern extent of the proposed water supply pipelines.

Two species (Greater Bilby and Princess Parrot) are more general in their habitat use across arid Australia, and could occur in any part of the study area. That said, the Greater bilby (a burrowing species) is probably more likely to use sandy habitats (rather than rocky habitats or habitats with heavier clay soils), which are more conducive to digging. Therefore, both the Greater bilby and also the Princess Parrot are more likely to occur within the sandy habitats of the borefield.

Minimising impacts on all these species and their habitats will serve to minimise impacts on most if not all other threatened and near threatened (i.e., as listed under the TPWC Act) species.

10.10.1 Recommendations

This assessment resulted in the detection of two EPBC Act-listed fauna species in the study area, and identified two others that could also occur there. Recommendations made here focus on those species. In particular, they focus on the mitigation and management of impacts to these species during the construction and operation of the Project.

The following are recommended:

- Prepare a Biodiversity Management Plan
- Construction and operation of the Project across the entire study area must be kept within the minimal possible area
- Undertake representative sampling/assessment in an effort to learn and contribute to the known information about these species in this region of the NT.

More information and recommendations are described in the Fauna report (Appendix N).

Key to Table:

EPBC	Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*						
TPWC	*Territory Parks and Wildlife Conservation Act 2006*						
EX	Extinct	EW	Extinct in the wild	CR	Critically endangered	NT	Lower risk - near threatened
EN	Endangered	DD	Data deficient	VU	Vulnerable	RX	Regionally extinct
PMST	Identified by the PMST search tool of the EPBC Act			GHD	Detected during 2010/11 or 2015 survey		
LRMDLRM	Recorded on the DLRM list (within 20 km of study area)			BPB	Recorded on the list for the Burt Plain Bioregion		

Likelihood of occurrence of fauna is assessed on a 4-tier scale:

1: **Present** – observed during the 2010 or 2015 baseline fauna surveys;
2: **Possible** - suitable habitat occurs within the study area, and site is within species' normal range;
3: **Unlikely** - suitable habitat does not occur within the study area, or suitable habitat present but substantially modified or degraded;
4: **Highly unlikely** – no suitable habitat within the study area and site is outside species' normal range.

Species	EPBC	TPWC	Source	Most recent record (DLRM or other)	Likelihood of occurrence within the study area	Comments
MAMMALS						
Black-footed Rock-wallaby (MacDonnell Ranges race) *Petrogale lateralis*	VU	NT	GHD, DLRM, PMST, BPB	2011 GHD 1987 DLRM	**Present** - Mine site **Unlikely** - all other areas	Results from scat samples collected in 2011 suggest that this species occasionally passes through the mine site and follow up surveys confirmed that a reproductive population exists in the vicinity of the mine site and surrounding ranges, extending down to outcrops in the southern borefield area (e.g. Reaphook Hills). Suitable habitat for this species is present within the rocky outcrops of the mine site, with habitat connectivity to other ranges nearby, suggesting that a larger population persists in the Reynolds Range area. Two waste rock dumps at the west of the mine site will directly impact a small area of likely habitat. Most of the habitat in the area surrounding the Mineral Lease will not be directly impacted by the Project.

Species	EPBC	TPWC	Source	Most recent record (DLRM or other)	Likelihood of occurrence within the study area	Comments
Greater Bilby (Bilby) *Macrotis lagotis*	VU	VU	PMST, BPB	-	**Possible** – all areas, but particularly in sandplain areas in southern parts of study area	Not recorded during the 2010 or 2015 surveys, and no records exist for the study area, although suitable habitat is present. Spinifex-dominated habitats within the study area provide potential habitat, including rocky areas and areas with a low shrub cover. Species occupies vegetation types including open tussock grassland on uplands and hills, mulga woodland/shrubland growing on ridges and rises, and hummock grassland in plains and alluvial areas (Southgate 1990b). In favourable conditions, populations can expand rapidly in abundance and occupied area (Woinarski et al. 2007). Species once widespread across NT, but populations declined dramatically following European settlement. The Greater Bilby is now generally reported from the western deserts region of NT, although other sightings occur occasionally. Species considered likely to still be present in this part of NT, albeit probably in small numbers. Species known from the Burt Plain Bioregion.
BIRDS						
Princess Parrot *Polytelis alexandrae*	VU	VU	PMST, BPB	-	**Unlikely** – Mine site **Possible** – all other areas	Not recorded during the surveys and no records exist for the study area, although suitable habitat is present. Species has patchy and irregular distribution in arid Australia. In NT, it occurs in the southern section of the Tanami Desert south to Angas Downs and Yulara and east to Alice Springs. The exact distribution within this range is not well understood. Few locations exist in the Northern Territory where the species is regularly seen, and even then there may be long intervals (up to 20 years) between records. Most records from the MacDonnell Ranges Bioregion are during dry periods (DLRM 2006). Species considered unlikely to use habitats within the mine site due to the absence of dune and swale habitats (although species has been recorded in riverine, woodland and shrubland habitat occasionally; Woinarski et al. 2007). Sandplain habitats in the borefield area provide potential foraging habitat for this species, with potential nesting sites also occurring in the sparse hollow-bearing trees. Possible occasional visitor.

Species	EPBC	TPWC	Source	Most recent record (DLRM or other)	Likelihood of occurrence within the study area	Comments
REPTILES						
Great Desert Skink *Liopholis kintorei*	VU	VU	GHD 2015; DLRM, PMST, BPB	2015 GHD; DLRM - no date	**Present** - Borefield area **Possible** - Processing site **Unlikely** - Mine site	Burrow/latrine system seen in borefield area during GHD 2015 survey. NT Fauna Atlas indicates one undated record, also in the borefield area (near Napperby Road). This species inhabits large complex burrows in a variety of desert habitats on sandy, clay and loamy soils (Cogger, 2000 cited in DotE 2015). It occurs on sand plains and on the flats between low sand dunes, preferring areas vegetated with spinifex clumps and scattered shrubs (Paltridge and McAlpin, 2002 cited in DotE 2015). Habitats for this species within the mine site are limited and this species is considered unlikely to occur there. However, sand plain habitats located in the borefield area and parts of the processing area support the preferred spinifex clumps with scattered shrubs occupied by this species in other areas.

11

Human health and safety

11. Human health and safety

11.1 Introduction

This chapter describes the potential impacts to human health and safety from the Nolans Project. A detailed human health and safety assessment report is provided in Appendix O of the EIS.

Section 5.6 of the TOR for the preparation of an environmental impact assessment issued by the NT EPA for the Nolans Project provided the following environmental objectives in relation to human health and safety:

The EIS should demonstrate that for all stages of the project:

- *The proponent is fully aware of the potential impacts to human health and safety*
- *All identified potential impacts to human health and safety will be avoided, mitigated or minimised*

This chapter addresses the potential impacts to human health and safety associated with all stages and components of the Nolans Project. It includes risks to the workforce and the general public for the duration of the Nolans Project, including post-closure, as required in the TOR for the Nolans Project.

11.2 Methodology

A summary of the approach to human health and safety assessment is described below and more detail is provided in Appendix O.

The assessment included the following steps:

- Identification of hazards which may lead to or contribute to human health and safety risks, comprising:
  - desktop analysis, based on typical hazards encountered for an open cut mining operation and associated processing facilities
  - a risk assessment workshop.
- Qualitative risk assessment to ascertain the level of risk associated with the identified hazards.
- Assessment of the risks against the qualitative risk criteria.
- Identification of management, preventative, treatment and monitoring strategies to minimise the impacts of the Nolans Project.

The assessment did not include human health and safety risks associated with radiation exposure. These are addressed separately in Chapter 12 and Appendix P of this EIS.

The risks associated with the Nolans Project have been determined by combining the likelihood of the potentially hazardous events and the magnitude of their consequences. This is based on *AS/NZS ISO 31000:2009, Risk management - Principles and guidelines.* The process involves the combining of consequences and frequencies which provides an appropriate weight to the range between small consequence events (which could be relatively frequent) and events of major consequence (which could be very infrequent). Risk assessment methodology is discussed further in Appendix O.

The causes that could lead each hazard to becoming a risk were identified and the associated controls / safeguards were also identified. These safeguards (outlined in Appendix O) are required so that the risk scenarios are contained or at least controlled to an acceptable level.

11.3 Assessment of potential impacts

11.3.1 Overview of risks

A total of 25 hazards were identified that could result in a risk to the workforce or the general public. The only human health and safety hazard identified and assessed to have the potential to impact surrounding land users was associated with off-site transport activities. All other hazards were considered to be containable within the Nolans site.

All human health and safety hazards were assessed as having a medium or above residual risk level. This is due to the focus of the hazard identification being on the higher consequence events, to enable early identification of these events and therefore greater ability to design them out of the operations. The risk levels were generally due to the consequence categories of major and catastrophic being selected as the maximum credible outcomes.

A summary of the hazard identification results are provided in Table 11-1, showing the hazard and maximum credible consequence identified. The full risk register for human health and safety risks is provided in Appendix O.

Table 11-1 Hazards to human health and safety

Potential event (hazard)	Potential impact (maximum credible consequence)	Managed Risk Level	Residual Risk Level
External bushfire, resulting in structural failures and release of process consumables, products or ignition of gas inventory.	Personnel fatality or injury.	Medium	Medium
Mobile equipment incident off site including vehicle to vehicle impact, single vehicle incidents (rollover, vehicle over the edge, vehicle impact with structure) and vehicle to pedestrian impacts.	Consequences will vary depending on severity of impact between minor injury to fatality. Maximum credible consequence could be a multiple fatality event when multiple vehicles are involved or multiple personnel in the vehicle(s). The event may occur at any time throughout the life of the Nolans Project.	High	High
Mobile equipment incident on site including vehicle to vehicle impact, single vehicle incidents (rollover, vehicle over the edge, vehicle impact with structure) and vehicle to pedestrian impacts.	Consequences will vary depending on severity of impact between minor injury to fatality. Maximum credible consequence could be a multiple fatality event when multiple vehicles are involved or multiple personnel in the vehicle(s). The event may occur at any time throughout the life of the Nolans Project.	High	High
Personnel falling from height or into depth on site including mining, processing, maintenance and administration areas.	Consequences will vary depending on the height and location of the fall between minor injury to fatality. Maximum credible consequence would be a single fatality (multiple fatalities may occur e.g. failure of scaffold with multiple personnel on it, however the more credible outcome is assumed to be a single fatality). The event may occur at any time throughout the life of the Nolans Project.	Medium	Medium
Personnel exposed to a confined space incident e.g. engulfment, irrespirable or noxious atmosphere.	Consequences will vary depending on the situation and will range between injury to fatality. Maximum credible consequence would be a multiple fatality event as it is likely that more than one person will be within a confined space. The event may occur at any time throughout the life of the Nolans Project, however is considered most likely during the operational phase.	Medium	Medium

Potential event (hazard)	Potential impact (maximum credible consequence)	Managed Risk Level	Residual Risk Level
Personnel struck by ground failure, rock fall or flyrock event in mining operational areas. Includes material falling from high and low walls, dumps and ramps, falling from loaded trucks.	Consequences will vary depending on the size of material falling and how personnel are impacted (e.g. on foot or in vehicle) and will range between injury to fatality. Maximum credible consequence would be a single fatality event as it is unlikely that more than one person will be impacted by a failure. The event may occur at any time throughout the life of the Nolans Project.	Medium	Medium
Personnel in contact with an electrical source (low or high voltage) resulting in electrocution or arc flash burns. This includes all electrical sources on site where exposure may occur during construction or operations.	Consequences will vary depending on the type of contact and energy level associated with the equipment. This would include a range of minor injuries e.g. electric shock, through to electrocution or fatality from arc flash events. The maximum credible consequence would be a single fatality. The event may occur at any time throughout the life of the Nolans Project.	Medium	Medium
Personnel struck by a dropped or swinging load during lifting by a lifting device or tipping a lifting device.	Consequences will vary depending on the size of the item that falls and the height from which it falls, ranging from an injury to a fatality. The maximum credible consequence would be a single fatality. The event may occur at any time throughout the life of the Nolans Project.	Medium	Medium
Personnel impacted by fire or explosion. This includes equipment and substance fire and explosions. This may occur during construction or operations. Mining operations fires would typically involve mobile equipment fires. Processing plant fires would typically involve fixed plant fires. This also includes the gas fired power generation plant and Amadeus Basin to Darwin high pressure gas pipeline.	Consequences will vary depending on the size and type of fire and extent of exposure. Personnel may be impacted by smoke, heat radiation from the fire or explosion overpressure. Consequences may range from smoke inhalation, minor burns through to fatality. The maximum credible consequence is a multiple fatality event as there is potential for multiple personnel to be impacted in a large fire or explosion event. The event may occur at any time throughout the life of the Nolans Project.	Medium	Medium

Potential event (hazard)	Potential impact (maximum credible consequence)	Managed Risk Level	Residual Risk Level
Personnel impacted by an explosives incident during transport, handling, storage or use on site. Potential incidents include misfires, fly rock, person in proximity to a blast and unintended initiation of an explosion.	Consequences will vary depending on the type of exposure and proximity to the event. Consequences may range from minor injury through to fatality. The maximum credible consequence is a single fatality. The event may occur at any time throughout the life of the Nolans Project.	Medium	Medium
Personnel impacted by a tyre or rim incident associated with mobile equipment.	Consequences will vary depending on the type of exposure and proximity to the event. Personnel may experience projectile / pressure impacts due to tyre pressure release, burns or pressure impacts from tyre fires and crush injuries due to dropped tyres. Consequences may range from minor injury through to fatality. The maximum credible consequence is a single fatality. The event may occur at any time throughout the life of the Nolans Project.	Medium	Medium
Personnel exposed to a flood or inrush event into the pit or personnel exposed to flooding within the mine lease e.g. low lying vehicle crossings or dam failures.	Consequences will vary depending on the extent of material released and the material being released. Groundwater and flooding events may result in injury e.g. due to slips, trips & falls through to fatality e.g. due to being trapped in a submerged vehicle / drowning. Dam failures may result in injury e.g. due to exposure to tailings products through to fatality from engulfment. The maximum credible consequence is a single fatality on the basis of the proximity of personnel to dams and anticipated volumes of material released.	Medium	Medium

Potential event (hazard)	Potential impact (maximum credible consequence)	Managed Risk Level	Residual Risk Level
Personnel struck by falling or dropped objects including structural failure.	Consequences will vary depending on the size of the item that falls and the height from which it falls, ranging from an injury to a fatality. The maximum credible consequence would be a single fatality. The event may occur at any time throughout the life of the Nolans Project.	Medium	Medium
Personnel caught in rotating or moving equipment. This may occur during construction or operations.	Consequences will vary depending on the equipment personnel are drawn into and how they are drawn in, potentially resulting in entanglement and entrapment. This may lead to crush injuries e.g. fingers, amputation of limbs or fatality. The maximum credible consequence would be a single fatality. The event may occur at any time throughout the life of the Nolans Project.	Medium	Medium
Personnel impacted by a high pressure release (stored energy). This may occur during construction or operations.	Consequences will vary depending on the pressure at time of release, proximity of personnel to the release and the material released. This may lead to fluid injection injuries if personnel are in close proximity or they may be struck by flying debris resulting in either an injury or fatality if the object is large enough or where it strikes the person. The maximum credible consequence would be a single fatality. The event may occur at any time throughout the life of the Nolans Project.	Medium	Medium
Personnel drowning while working in or around liquid bodies.	Consequences may include minor injuries e.g. due to trips and falls through to fatality (drowning). The maximum credible consequence would be a single fatality. The event may occur at any time throughout the life of the Nolans Project.	Medium	Medium

Potential event (hazard)	Potential impact (maximum credible consequence)	Managed Risk Level	Residual Risk Level
Personnel exposed to hazardous materials via all means e.g. ingestion, inhalation or skin contact.	Consequences will vary depending on the material personnel are exposed to, the means of exposure and the duration of exposure. Consequences range from: - irritation to skin, eyes and respiratory system e.g. due to exposure to sulfur, lime, limestone, sodium sulfate, barium chloride, sodium carbonate; - bronchitis and silicosis e.g. due to prolonged inhalation exposure to lime; - severe chemical burns and potentially fatality e.g., due to exposure to hydrochloric acid, sulfuric acid, and sodium hydroxide; - respiratory and heart failure and potentially fatality due to ingestion of barium chloride. The maximum credible consequence would be a multiple fatality, for example due to a catastrophic failure of the concentrated sulphuric acid tank. The event is most likely to occur during the operations phase of the Nolans Project.	Medium	Medium
Personnel impacted by climatic extremes while working on site in adverse weather conditions.	Consequences will vary depending on the type of exposure, where effects may range from dehydration, sunburn, injuries from being struck by items through to fatality due to heat stroke, struck by lightning or major building / structural failures. The maximum credible consequence would be a single fatality as it is considered unlikely for multiple people to be impacted by a single climatic event. The event may occur at any time throughout the life of the Nolans Project.	Medium	Medium
Engulfment of personnel in RE materials while working on site on stockpiles, ROM or around bins, hoppers, chutes etc. Personnel may be engulfed while on foot or in mobile equipment.	Consequences will vary depending on the volume of material in which personnel are engulfed and the ability to self-rescue. The maximum credible consequence would be a single fatality. The event may occur at any time throughout the life of the Nolans Project.	Medium	Medium

Potential event (hazard)	Potential impact (maximum credible consequence)	Managed Risk Level	Residual Risk Level
Personnel exposed to hazardous flora or fauna including snakes, spiders, mosquitoes, biting insects, bees, wasps, larger animals such as dingoes / wild dogs, wild pigs etc.	Consequences will vary depending on the flora or fauna to which personnel come into contact and whether or not they have an allergic reaction to bites / stings. The maximum credible consequence would be a single fatality. The event may occur at any time throughout the life of the Nolans Project.	Medium	Medium
Unauthorised site access / security breach during construction and operation.	Consequences will vary depending on the location of unauthorised access and the reason for access (e.g. if they are deliberately causing harm). Personnel may be exposed to many of the site hazards including mobile equipment movements, residue storage facilities, hazardous chemical etc. The maximum credible consequence would be a single fatality. The event may occur at any time throughout the life of the Nolans Project.	Medium	Medium
Personnel exposed to increased noise levels during construction and operation of the mine, RE intermediate plant and associated infrastructure.	Consequences of cumulative noise exposure will be an increased risk of industrial noise induced hearing loss (NIHL). The event may occur at any time throughout the life of the Nolans Project.	Medium	Medium
Personnel exposure to whole body vibration during operation of mobile equipment in mining operations.	Consequences of whole body vibration will ultimately be muscular skeletal disorders. The event is most likely to occur during the operational phase of the Nolans Project.	Medium	Medium
Personnel exposed to increased risks due to the remote location of the site and / or undertaking lone and isolated work.	Although the initial injury may not be immediately life threatening, there is potential for the situation to escalate due to the distance and time it takes for medical aid. The maximum credible consequence would be a single fatality. The event may occur at any time throughout the life of the Nolans Project.	Medium	Medium

Potential event (hazard)	Potential impact (maximum credible consequence)	Managed Risk Level	Residual Risk Level
Manual handing injuries during manual work conducted on site across the operations.	Manual handling injuries may include back injuries such as injuries to nerves, bones, joints and soft tissue hernias, ruptured discs and torn back muscles. Other consequences may include sprains of ligaments, strains of muscles or tendons, tendonitis, spondylolisthesis, carpel tunnel syndrome and Repetitive Strain Injury. The maximum credible consequence would be musculoskeletal effects to bones and soft tissue structures. The event may occur at any time throughout the life of the Nolans Project.	Medium	Medium

11.3.2 Transport related risks

The two highest risks identified for human health and safety were in relation to vehicle movements and the management of traffic on and off-site. The top two risks include:

- Vehicle incidents associated with the transport of materials and personnel off-site on public roads, including vehicle to vehicle impact, single vehicle incidents (rollover, vehicle over the edge, vehicle impact with structure) and vehicle to pedestrian impacts.
- Mobile equipment incidents on site including vehicle to vehicle impact, single vehicle incidents (rollover, vehicle over the edge, vehicle impact with structure) and vehicle to pedestrian impacts.

Although controls have been identified (refer section 11.4.3), it is not anticipated to reduce the likelihood from unlikely or the consequence from catastrophic due to the sensitivity of the qualitative risk assessment technique. Therefore, the risk level remains high.

11.3.3 Ground control risks

Inherent within a mining operation is the risk of ground failure or rock fall events. Within the project human health and safety risk assessment, ground failure or rock fall leading to a person being struck and injured was assessed as a medium risk. Although the consequence is major (potential for fatality), the likelihood is considered to be low (rare) due to the proposed controls that will be implemented and due to the fact that this type of event is more likely to occur in underground mining than in open pit mining.

11.3.4 Hazardous material exposure

The potential for personnel to be exposed to hazardous materials was identified as a risk associated with the Nolans Project, particularly for the processing facilities. Materials identified that may cause harm to personnel include sulfur, lime, limestone, hydrochloric acid, hydrogen fluoride, sodium hydroxide, sodium sulfate, sulfuric acid, barium chloride, sodium carbonate, chlorine, fire suppression chemicals, rare earth intermediate products, tailings, process residues, sewage.

All critical gaseous emissions from the process, including hydrogen fluoride and chlorine, will be captured using scrubbing systems. These are being incorporated into the engineering design.

Personnel may be exposed in a number of ways including during transport and storage or use of the materials. In the event of exposure, consequences will depend on the extent of exposure and the material, therefore it may range from minor consequences such as irritation to skin or the maximum consequence of fatalities, for example due to a catastrophic release of concentrated sulfuric acid.

11.3.5 Fire risks

Due to the presence of flammable and combustible materials, there is a potential for fire and explosion events. While the consequences may be catastrophic (fatalities), the likelihood is low (rare) due to the controls that will be implemented; therefore, this was assessed as a medium risk.

Scenarios may include equipment (e.g. mobile equipment and fixed plant fires), and substance fire and explosions, for example, diesel storage, gas fired power generation plant and Amadeus Basin to Darwin high pressure gas pipeline. There is also a potential for bushfires to occur which expose personnel to health and safety risks.

11.3.6 Climate extremes

The location of the Nolans site is in an area with high ambient air temperatures, therefore personnel may be exposed to adverse effects as a result of climatic extremes. This includes high winds, lightning, storms, hail, heat, ultra violet radiation.

When working in hot conditions, heat exposure is considered one of the higher risk scenarios which may lead to heat stress or heat stroke. Although it is considered unlikely due to the controls in place, there is a potential for fatality to occur as a result of climate extremes.

There are design features that will assist in reducing the risk of climatic extremes such as equipment design specifications taking into account wind loading, ventilation, lagging of hot surfaces, cooling systems and lightning arrestors.

11.3.7 Remote area risks

Personnel may be exposed to increased risks due to the remote location of the site and / or undertaking lone and isolated work at the Nolans site; this is due to the increased time for emergency response, potential communication failures, black spots and long travel distances. This includes personnel such as exploration crews (drillers, geologists etc.), surveyors, shot firers, pump crew, supervisors, environmental specialists and third party contractors (electrical personnel, fitters.).

Although the initial incident may not be immediately life threatening, there is potential for the situation to escalate due to the distance and time it takes for medical aid. Therefore, to reduce the risk associated with the remote location, additional control measures are identified in Section 11.4.8.

11.4 Control measures and monitoring

11.4.1 Engineering and operational controls

The engineering controls identified within the human health and safety risk register (refer Appendix O) will be built into the design of the site and associated infrastructure as the Nolans Project progresses. Operational controls will be developed during the design and construction phases and implemented for hand over to operations.

11.4.2 General administrative controls

A health and safety management system will be implemented and used as the basis for the management of all aspects of human health and safety for the Nolans Project. The structure of the management system will be based on guidance provided by WorkSafe Australia and AS/NZS 4801:2001 Occupational Health and Safety Management Systems; and will include the following elements:

- monitoring
- auditing
- review
- improvement cycles.

Risk management procedures will be prepared. Maintenance of a site specific risk register will be required to identify and assess risks to human health and safety throughout the Nolans Project lifecycle to ensure those risks are minimised. The risk register will be a live document, formally reviewed on a regular basis to assess the operations and put in place appropriate control measures to prevent and / or mitigate the risks.

A hierarchy of control will be established and implemented to its fullest extent. During the design stages, control strategies higher in the hierarchy can be applied to eliminate, substitute, isolate or engineer the site, infrastructure and equipment to reduce the risks so far is reasonably practicable.

An incident management system will be established and implemented which will identify the hazards and system deficiencies to prevent an incident reoccurring through an investigation and corrective action process. An incident management process will be implemented to enable:

- On-going identification of hazards and reporting of incidents by any site personnel
- Investigation of all reported incidents
- Follow up and close-out of identified corrective actions
- Communication of incidents across the organisation and statutory reporting, if required,
- Use of findings from incident investigations to improve systems, processes and procedures.

An emergency response strategy will be established (See also Appendix X, Emergency Response Management Plan). This will incorporate the emergency response systems, procedures, scenario specific emergency response plans and resources. The emergency response strategy will be managed by the site emergency response team consisting of dedicated staff. All personnel within the emergency response team will undergo regular training and participate in regular mock and desktop exercises.

A regular audit program will be implemented to confirm compliance with the health and safety legislative requirements and company / operations specific processes and procedures. This will also include independent external authorities conducting audits as necessary.

It is intended that emergency response planning will also incorporate actions to manage incidents that might occur off the Nolans site. This would relate to incidents where reagents in transit to the site may have spilled or leaked or as the result of a vehicle accident resulting in a loss of containment. The ERP will provide direction and advice to emergency response personnel who may have statutory responsibility for the clean -up actions for these incidents to ensure they are aware of the hazards associated with the product with which they are dealing.

11.4.3 Transport related controls

To manage the vehicle related risks 'so far as reasonably practicable', the proposed control measures that will be implemented for the Nolans Project were identified as:

- Design features such as:
  - Segregation between vehicles and vehicles / pedestrians e.g. road access restrictions, dedicated walkways
  - Road design to relevant standards
  - Dedicated laydown / hardstand areas
  - Vehicle design specifications and associated procurement management
  - Vehicle decals and flags, flashing lights
- Traffic Management Plan which details;
  - Authorisation process for vehicles to enter site
  - Access restrictions to operational areas e.g. through the use of barricades;
  - Site speed restrictions
  - Vehicle maintenance program including pre-start inspections and routine maintenance

- – Road maintenance program, including dust suppression
- – Change management
- – Equipment and task specific procedures / work instructions
- – Equipment and task specific training and competency assessment (including ongoing refresher)
- – Fitness for work management system including hours of work, drug & alcohol policy, medicals, fatigue management.)
- – High visibility PPE.

In addition to the above controls, further systems and processes will be implemented to manage off site vehicle related risks. These include:

- Audit of service provider during selection process to encourage competence and professionalism;
- Transport study and associated management systems
- Journey management plans (including minimising travel during dusk / dawn)
- Contractor management system
- National Heavy Vehicle Regulator Scheme accreditation
- Speed limiting on heavy vehicles
- Community consultation and awareness program.

The transport of dangerous goods will be conducted in accordance with the *Northern Territory Transport of Dangerous Goods Act* (2015) & *Regulations* (2011) and *Australian Dangerous Goods Code 7.3.*

Additional controls have been identified for both vehicle and mobile equipment incidents. This includes in vehicle monitoring systems to track driver behaviour, proximity detection systems and alarms, accident/incident investigation protocols and quarterly road safety briefings.

11.4.4 Ground control risks

The following controls will be implemented to manage risks identified from the mining operation such as ground failure or rock fall events:

- Mine design (including review and sign-off processes)
- Mine modelling and mapping (hydrogeological, geological, exploration data etc.)
- Mine geological and geotechnical monitoring e.g. Global positioning system (GPS) tracking of faults, daily inspections, ground monitoring systems (prism, extensometers, radar, piezometer, survey)
- Geotechnical hazard maps
- Trigger action response plans
- Mine drainage design and systems
- Water management plan
- Blasting design including blasting management and clearance
- Blast vibration monitoring
- Equipment and task specific procedures / work instructions

- Equipment and task specific training and competency assessment (including ongoing refresher)
- Falling object protection systems (FOPS) on mobile equipment
- Access restrictions to pit ramps, slopes and crests
- Hazard reporting.

No further controls were identified for implementation other than those already planned, therefore the risk remains as medium, However, through the ongoing risk management process, if any new technologies or processes are identified that may reduce the risk, these will be considered.

11.4.5 Hazardous material exposure

Controls have been identified to reduce hazardous material exposure risk, including controls that will be taken into account within the design of the facilities. The Hazardous Substances Management Plan (See Appendix X, EMP) provides a framework for the management of hazardous substances and will include:

- Hazardous substance storage and handling system design specifications
- Plant process control
- Storage, handling and spill management requirements as specified in the Safety Data Sheets, ChemAlert database and legislative requirements for the *Northern Territory Transport of Dangerous Goods Act* (2015) & *Regulations* (2011) and *Australian Dangerous Goods Code 7.3*
- Inspection and maintenance of hazardous substance storage systems
- Spill kits
- Procedure for transport and storage of hazardous substances
- Equipment and task specific procedures / work instructions
- Equipment and task specific training and competency assessment (including ongoing refresher)
- Isolation procedure and associated training
- PPE (eye protection, breathing apparatus, gloves etc.)
- Signage / labelling of equipment containing hazardous substances
- Site induction.

11.4.6 Fire risks

Controls to minimise fire risk will be developed during the design stage of the Nolans Project. Additional controls will be developed and implemented throughout operations. Some control strategies include:

- Fixed plant and mobile equipment design specifications and associated procurement management
- Hazardous substance storage and handling system design specifications
- Fire detection and suppression systems, fire extinguishers and firefighting training
- Lightning arrestors

- Fixed plant and mobile equipment maintenance program including pre-start inspections and routine maintenance
- Gas pipeline design and SMS (AS 2884)
- Inspection and maintenance of hazardous substance storage systems
- Electrical protection systems
- Thermographic monitoring
- Operational procedures including transport and storage of hazardous substances, isolation, excavation / dig permit; hot work procedure and permit
- Signage and demarcation of gas pipeline
- Fire breaks, cool-season controlled burns, vegetation reduction program and
- Fire management plan.

11.4.7 Climate extremes

In addition to the design features that will assist in reducing the risk of climatic extremes (Section 11.3.6), there will also be a number of administrative controls used during operations to reduce the effects of climate extremes such as:

- Fitness for work management system including hours of work, drug and alcohol policy, medicals, fatigue management)
- Adverse weather procedure (including weather monitoring and stop work requirements)
- Trigger action response plans (actions to be taken if the monitored parameter is above the trigger value, with escalation processes for increasing trigger values)
- Lone and isolated workers' procedure
- Heat reducing PPE
- Heat stress / hydration monitoring and provision of camel backs / electrolyte replacement drinks
- Scheduling work to avoid hottest time of day
- Communication protocols.

11.4.8 Remote area risks

Although the initial incident may not be immediately life threatening, there is potential for the situation to escalate due to the distance and time it takes for medical aid. Therefore, to reduce the risk associated with the remote location the following controls will be implemented:

- Controls listed in Section 11.4.7
- Journey management plans
- Communication equipment suitable for the area and activity
- Vehicles fitted with recovery equipment, first aid kits, water supply etc.
- Emergency response procedures, team and equipment, specifically incorporating the limitations associated with the remote location
- Man-down alarms.

12

Radiation

12. Radiation

12.1 Introduction

This chapter provides an overview of the radiological environment of the Nolans Project including a summary of the natural levels of background radiation in the region and impacts from operating the project on workers, the public and the environment.

Detailed radiation reports are provided in Appendix P, including:

- Sonter, M. & Hondros, J. 2016, *Occupational and Environmental Radiation Measurements and Predictions*, Radiation report prepared for Arafura Resources Ltd, Noland Project, March 2016
- JRHC, 2016, *Nolans Rare Earths Project: Environmental and Public Radiation Technical Report*, JRHC Enterprises 2015
- Hussey, K. 2016, *Environmental Radiation and Geochemical Studies Associated with The Nolans Project EIS, Discussion And Analysis Of Some Results*, Arafura Resources Report ARU-15/008.

The TOR for the preparation for the project provided the following environmental objective in relation to radiation:

> *For all stages of the Project the Proponent is fully aware of potential for the Project to cause harmful radiation doses to people and/or the environment, proposed management will protect all people and the environment from harmful radiation doses resulting from the Project.*

This chapter addresses sections 21 and 22A under the EPBC Act (refer section 1.1.4).

This chapter also addresses the design, construction and operation of the proposed project to ensure that human and environmental radiation impacts comply with all legal requirements, Australian standards, codes of practice and guidelines as required in the TOR.

12.2 Methodology

Radiation doses to workers and to members of the public are regulated in all Australian States and Territories under the relevant state Radiation Safety, Control or Protection Acts and associated Regulations. The project would operate in the Northern Territory and would comply with all relevant Northern Territory legislation.

These Acts and Regulations in general conform with the codes and guidelines issued by the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA). The Australian approach is based on international guidance from the International Atomic Energy Agency (IAEA), the Recommendations of the International Commission on Radiological Protection (ICRP) and on the Reports of the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR).

The main ARPANSA radiation codes that apply to the project are:

- *Code of Practice on Radiation Protection and Radioactive Waste Management in Mining and Mineral Processing, 2005* (also known as the Mining Code) (ARPANSA 2005)
- *Code of Practice on the Transport of Radioactive Material* (also known as the Transport Code) (ARPANSA 2008).

The internationally recognised basis of radiation protection is the ICRP recommended 'System of Dose Limitation'. This requires that planned doses to workers or to members of the public from industrial activities need to be justified, optimised and limited. The method of dose assessment for workers and the public is based on the recognised methods of the ICRP as outlined in national standards, including the Mining Code and ARPANSA (2010).

For occupational doses, estimates are made for mining and processing plant personnel. The locations of interest for public dose have been identified for the project and are:

- The accommodation village, located approximately five kilometres from the processing plant and nine kilometres from the mine site (two exposure scenarios have been modelled – fulltime occupation of the village (8,760h/y) and part-time occupation (4,000h/y));
- Aileron (includes Aileron Roadhouse, campground and houses, and the Aileron Station Homestead and workers' accommodation), located approximately 12 kilometres from the processing plant and 13 kilometres from the mine site; and
- Alyuen Community, located approximately 12 kilometres from the processing plant and 15 kilometres from the mine site.

A conservative assessment was undertaken on the assumption that a person resides for a full year at the location of the accommodation village and consumes only food that grows there. This situation simulates a worst case assessment of potential member of the public dose.

The environmental impact is assessed based on determining a change in exposure rates to standard species of flora and fauna as a result of emissions from the operation.

The assessments are based on the results of air quality modelling which provides estimates of radiation levels in the wider environment as a result of airborne emissions from the project area. The preliminary air quality modelling has been completed and the results that have been used for the radiological impact assessment are as follows:

- Radon and thoron concentrations at a number of potential receptor locations
- Total dust deposition at Aileron and the accommodation village and
- Total suspended particulates dust concentrations at Aileron and the accommodation village location.

Full details of the methodology, limitations and assumptions are provided in Appendix P.

12.3 Existing environment

12.3.1 Overview

Arafura commenced comprehensive baseline radiological studies of the Nolans site and of the region, including environmental and occupational radiation sampling and monitoring, in 2005. These studies are documented in ANSTO (2007), Sonter (2016a), Dean and Grose (2015) and Hussey (2016), and considered the following:

- Gamma monitoring
- Soil and sediment sampling
- Vegetation sampling
- Groundwater sampling
- Dust sampling
- Passive radon and thoron and

- Real time radon and thoron monitoring.

Gamma monitoring

A general area survey was conducted in a grid pattern across the mine site area and at sites remote (background) from the project area. Background sites include two measurements in Kerosene Camp Creek and two measurements at the Aileron Roadhouse.

The measurements were taken at locations on and off the Nolans Bore deposit and a summary of the results are provided in Table 12-1.

Table 12-1 Summary of gamma measurements

	Environmental Gamma Dose Rate (µSv/h)			Number
	Average	Max.	Min.	
On Deposit	0.38	0.63	0.18	12
Off Deposit	0.19	0.35	0.13	37
Background	0.17	0.18	0.15	4

The gamma radiation levels in the region have been extensively studied through a number of surveys. The primary sampling locations and summary results are shown in Figure 12-1 and Table 12-2 respectively.

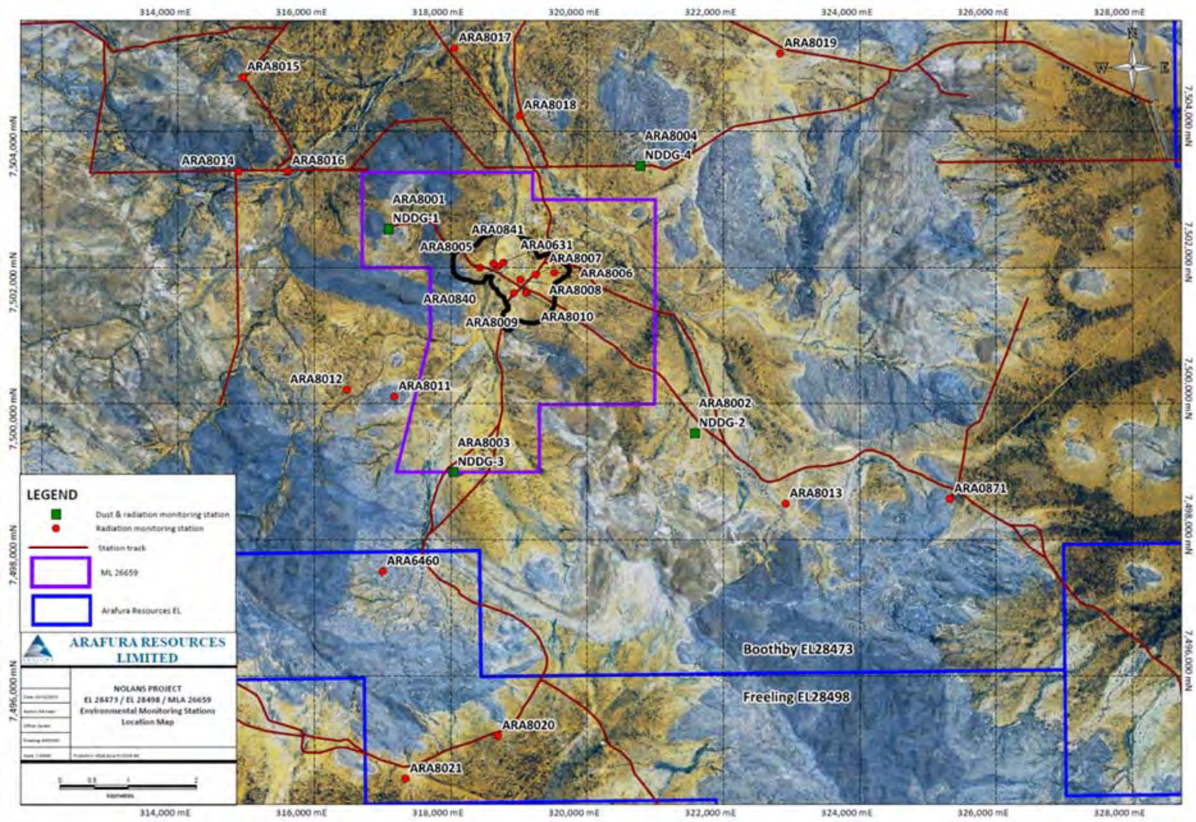


Figure 12-1 Location of environmental monitoring locations – Nolans site

Table 12-2 Summary of gamma monitoring results

Sample Program and Method	Average Results (µSv/h)
Nolans Bore (on deposit)	0.8 (highs to > 10)
Nolans Bore (off deposit)	0.25

Arafura has flown aerial radiometric surveys of the area and results are displayed in Figure 12-2.

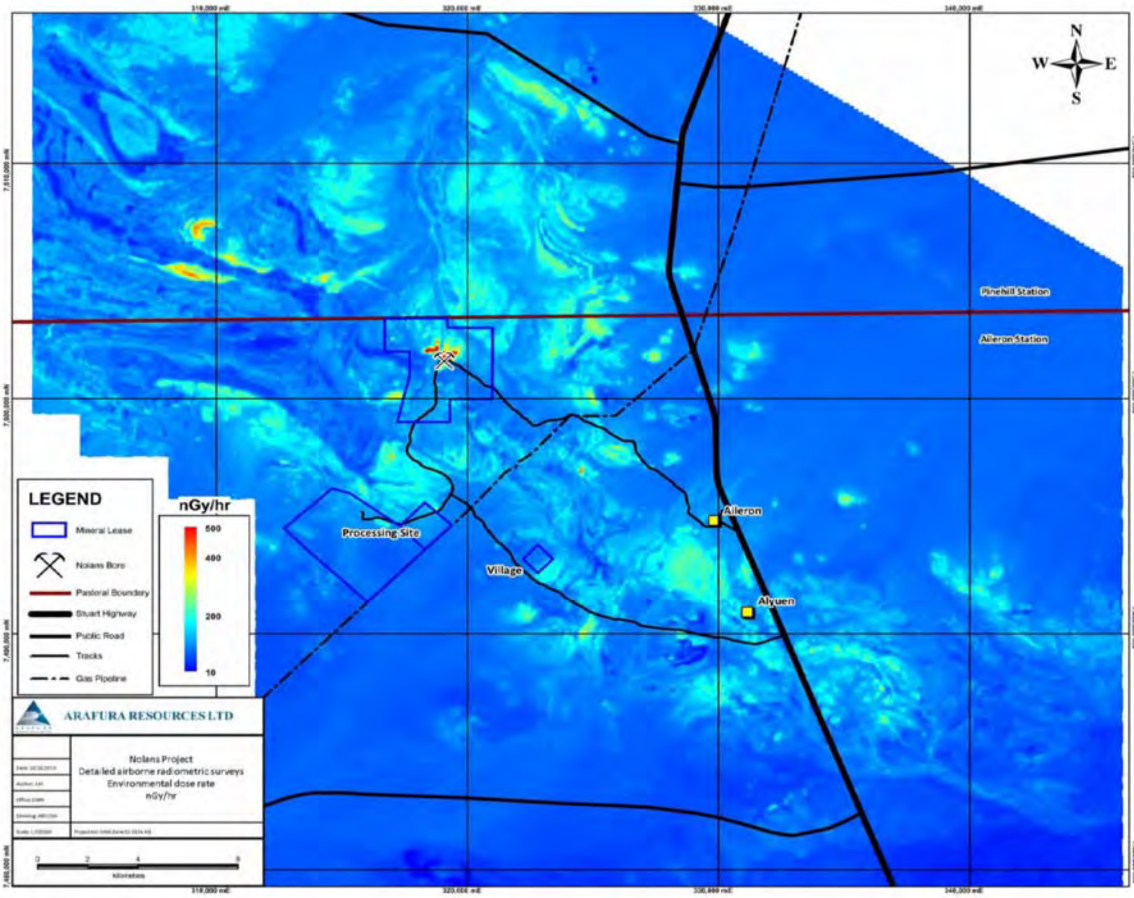


Figure 12-2 Aerial gamma surveys – Nolans Project area (Arafura 2009; Arafura 2013)

In general, the surveys provide consistent results and clearly show the gamma signature of the mineralised material and the large variation in gamma radiation across the region.

Typical gamma background levels across Australia are presented in Table 12-3.

Table 12-3 Environmental gamma results elsewhere in Australia

Location	Average Environmental Gamma Levels (µSv/h)	Reference
Australian average	0.07	Inferred from ARPANSA (2005)
Central South Australia	0.1	BHP Billiton (2009)
Honeymoon U deposit	0.1 (no surface outcrop)	Southern Cross Resources (2006)
Kintyre U deposit	0.09 (no surface outcrop)	Cameco (2013)
Mulga Rock U deposit	0.06 (no surface outcrop)	Vimy Resources (2015)
Lake Way U deposit (on deposit)	0.9	Toro Energy (2015)
Lake Way U deposit (off deposit)	0.1	Toro Energy (2015)
Yeelirrie U deposit (on deposit)	0.9	Cameco (2015)
Yeelirrie U deposit (off deposit)	0.09	Cameco (2015)

Soil and sediment samples

Surface soil sampling was undertaken at three locations: one upstream from the Nolans Bore deposit in the mine site (Area 1), one downstream (Area 2), and the third at a site distant (Background) from the project area near the Aileron Roadhouse. Results are presented in Table 12-4.

Table 12-4 Soil radionuclide analyses

	Radionuclide Concentration (Bq/kg)									
	U238	U234	Th230	Ra226	Pb210	Po210	Th232	Ra228	Th228	K40
Area 1	27	20	25	23	15	20	56	77	75	805
Area 2	25	18	24	18	10	17	32	42	42	891
Background	77	30	72	53	45	47	118	118	121	925

The results show that the concentrations of uranium and thorium in the soil samples from the roadhouse are naturally elevated compared to the samples from the mine region and comparable to the Australian average.

Extensive soil and sediment sampling has also been completed across the region, and these results are shown in Table 12-5.

Table 12-5 Summary of soil and sediment sampling

	Number of Assays	Uranium (average and range in parts per million (ppm))	Thorium (average and range in ppm)
Crustal average		2.7	10.5
Soils (on deposit)	9	22 (3.28-83.3)	328 (44.1-950)
Soils (off deposit)	17	5.51 (2.47-24.3)	63.2 (23.2-416)
First drill metre (on deposit)	142	55.6 (1.4-655)	791 (10.4-8730)
First drill metre (off deposit)	18	5.85 (1.6-19)	50.5 (9.55-149)
Stream sediments	51	3.16 (1.36-13.7)	44.5 (14.6-180)
Stream sediments (fine grained fraction)	51	8.21 (2.81-21.5)	119 (31.7-360)

Uranium and thorium concentrations for a range of samples have been determined and show that:

- Soils and stream sediments in the region have above crustal average uranium and thorium concentrations
- Uranium and thorium compositions of the soils and stream sediments are broadly similar
- Soils on top of the Nolans Bore deposit have higher average uranium and thorium compositions than those outside of the deposit, although there is considerable overlap and
- It is difficult to distinguish the stream sediment signature of the Nolans Bore deposit because of the masking effect of elevated levels of radioelements in the region.

Vegetation samples

Sampling of vegetation was undertaken at the same three locations as the soil samples. The results are shown in Table 12-6.

Table 12-6 Vegetation radionuclide analyses

	Radionuclide Concentration (Bq/kg)									
	U238	U234	Th230	Ra226	Pb210	Po210	Th232	Ra228	Th228	K40
Area 1	0.9	2.1	0.3	14.0	25.5	21.6	0.4	22.0	7.2	433
Area 2	1.3	2.3	1.0	8.5	29.0	19.5	2.4	20.0	7.5	609
Background	1.1	1.6	1.1	26.5	38.0	23.3	2.4	69.5	21.9	531

The enhanced concentrations of Po210 and Pb210 are generally observed and primarily due to the decay of atmospheric radon (UNSCEAR 2000).

Extensive vegetation sampling has also been completed across the region, and these results are shown in Table 12-7.

Table 12-7 Summary of vegetation sampling

	Number of Assays	Uranium (average and range in ppm)	Thorium (average and range in ppm)
Grass (on deposit)	9	0.022 (<0.01-0.06)	0.22 (0.1-0.39)
Grass (off deposit)	17	0.015 (<0.01-0.12)	0.14 (0.02-1.37)
Tree leaves (on deposit)	10	0.046 (<0.01-0.06)	0.15 (0.03-0.59)
Tree leaves (off deposit)	17	0.01 (<0.01-0.08)	0.02 (<0.01-0.04)
Tree leaves (on deposit)	75	0.077 (<0.01-0.48)	0.537 (0.01-5.31)
Tree leaves (off deposit)	1127	0.016 (<0.01-0.71)	0.021 (<0.01-0.34)

Groundwater samples

Two groundwater samples were taken and analysed. The results are presented in Table 12-8.

Table 12-9 presents the additional groundwater sampling within and upstream of the Nolans Bore deposit.

Table 12-8 Groundwater radionuclide analyses

	Radionuclide Concentration (Bq/L)									
	U238	U234	Th230	Ra226	Pb210	Po210	Th232	Ra228	Th228	K40
Nolan Bore (stock bore)	2.5	8.6	<0.05	0.15	<0.01	0.004	0.015	3.1	0.32	1.1
Aileron Roadhouse Bore	6.4	20.8	0.12	0.26	0.33	0.314	0.034	0.78	0.16	0.7

Table 12-9 Summary of groundwater sampling

	Number of Assays	Uranium (average in ppm)	Thorium (average in ppm)
In deposit	5	0.354	<0.0001
Upstream and off deposit	9	0.361	<0.0001

The results show that the groundwater radionuclide concentrations are elevated and highly variable across the region.

Dust Deposition

Dust deposition gauges were placed at four locations approximately two to three kilometres distant from the proposed mine area in approximately north west, south east, north east and south west directions, being downwind, upwind, and orthogonal to prevailing wind direction. A summary of the results are provided in Table 12-10.

Table 12-10 Dust deposition

	Total Dust Deposition ($g/m^2/day$)	Thorium Deposition ($\mu g/m^2/day$)	Uranium Deposition ($\mu g/m^2/day$)
NDDG-1 (NW)	0.067	0.36	0.20
NDDG-2 (SE)	0.017	0.16	0.07
NDDG-3 (SW)	0.041	0.40	0.29
NDDG-4 (NE)	0.025	0.14	0.08

The uranium and thorium concentrations in the deposited dust are relatively consistent at approximately 3 ppm and 10 ppm respectively. These figures are consistent with worldwide background levels of radionuclides in soils (UNSCEAR 2000).

For comparison, average dust deposition figures of 1.5 g/m^2/month were reported in the Kintyre region of Western Australia (Cameco 2013).

Dust concentrations in air

Between September 2010 and March 2011, dust concentration sampling was conducted to measure PM_{10} dust. The results show daily average PM_{10} dust concentrations varying between 1 and 35 $\mu g/m^3$ over the sampling period, with an average dust concentration of 16 $\mu g/m^3$. Radionuclide analyses were not conducted on the dust; however, based on the soil concentrations and the dust deposition results, giving uranium and thorium concentrations of 3ppm and 10ppm respectively, and assuming that the dust is resuspended soil, the radionuclide concentrations in air can be calculated. The results are 0.4 mBq/m^3 for uranium and 1.2 mBq/m^3 for thorium.

Radon and Thoron concentrations

During 2015, real time radon and thoron monitoring was carried out at Nolans Bore (Dean and Grose 2015; Sonter 2015). The results indicate a high level of variability in both radon and thoron concentrations, up to two orders of magnitude, consistent with variations observed elsewhere.

The natural airborne radon and thoron concentrations are variable, ranging well over an order of magnitude in a typical 24 hour cycle, and possibly up to three orders of magnitude (Figure 12-3).

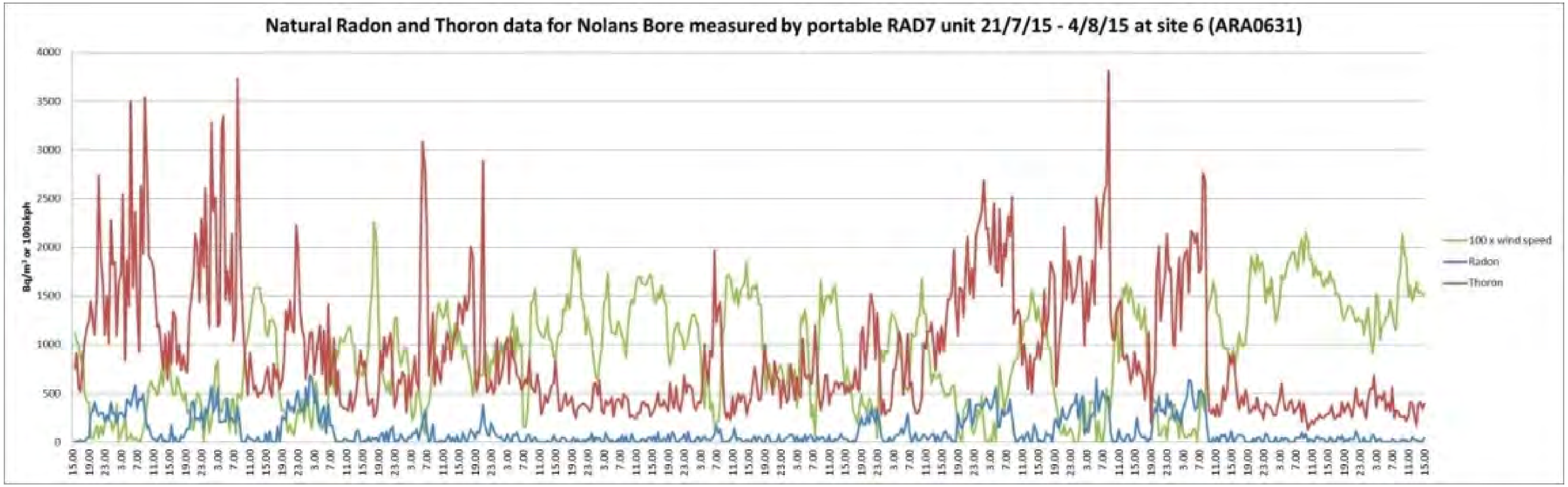


Figure 12-3 Real time radon and thoron concentrations

During the sampling period, the average radon concentrations were calculated to be approximately 80 Bq/m^3, with average thoron concentrations being approximately 800 Bq/m^3.

The thoron activity concentrations are significantly higher than the radon activity concentrations. However, this is as expected (Sonter and Hondros 2015) and due to both the higher thorium content of the outcropping deposit and the shorter half-life of the thoron.

In addition to real time monitoring, longer term concentration averages were determined. Detectors were placed into the field for a period of four months. The average concentrations of these results are provided in Table 12-11.

Table 12-11 Passive radon and thoron averages

Location	Average Concentration	
	Radon (Bq/m^3)	Thoron (Bq/m^3)
Within mine footprint	44	470
Outside mine footprint (regional)	29	120

During 2015, daily thoron decay product (TnDP) concentrations were manually monitored on the deposit at Nolans Bore at dawn and later afternoon each day (Sonter 2016a).

Average concentrations were:

- Morning – 0.166 $\mu J/m^3$
- Afternoon – 0.039 $\mu J/m^3$
- All average – 0.085 $\mu J/m^3$.

Manual grab sampling of radon decay product (RnDP) concentrations were undertaken during radiation monitoring campaigns in 2005 and 2008 (Sonter 2016a). A summary of the results is:

- 2005 sample average of 0.27 $\mu J/m^3$ (11 daytime samples)
- 2008 sample average of 0.02 $\mu J/m^3$ (27 daytime samples).

Note that the difference in averages is due to the time of year of samples. The 2005 samples were acquired during winter and the 2008 results were during summer.

The thoron concentration and thoron decay product monitoring data was used to calculate a naturally occurring equilibrium factor. This was shown to be very low, ranging from between 0.001 and 0.004 for the data obtained (Sonter and Hondros 2015).

Studies into radon emanation from ores were carried out on two drums of Nolans ore in 2015, giving approximately one $Bq/m^2/s$ for Rn222 and about 300 $Bq/m^2/s$ for Rn220 (Sonter 2016b).

The experimental emanation rates were extrapolated to the life of mine average uranium and thorium grades, giving 0.4 $Bq/m^2/s$ for radon and 200 $Bq/m^2/s$ for thoron.

12.3.2 Summary

The key findings from these extensive radiation studies are as follows:

- The project area is radiologically identified by the extensive near-surface orebody
- There are areas in the broader region that exhibit elevated gamma radiation levels
- The broader area is characterised by a large number of areas with higher concentrations of uranium and thorium compared to the Australian continent average
- There is elevated radon and thoron in the region due to the outcropping areas of elevated uranium and thorium
- Radon and thoron concentrations in the air are elevated near the deposit and vary by up to two to three orders of magnitude
- The Nolans Bore deposit has a radiological signature for thoron, radon and gamma radiation
- There is a clear variation in radon and radon decay product concentrations throughout the day and
- The thoron concentrations in the region are significant; however the thoron decay product concentrations are low as expected.

These findings, however, are not dissimilar to those found in the vicinity of other near-surface undeveloped uranium and rare earths orebodies.

12.4 Assessment of potential impacts

12.4.1 Radiation exposure to workers

For occupational doses, estimates are made for mining and processing plant personnel for the following exposure pathways:

- Gamma radiation
- Inhalation of radon decay product and thoron decay product and
- Inhalation of radionuclides in airborne dust.

The recognised limit for radiation doses to workers arising from work or industrial activities is 20 millisieverts per year (mSv/y), averaged over five years, with a maximum of 50mSv in any one year. For members of the public, the limit is 1.0 mSv/y (ARPANSA 2005).

The assessment indicates that the overall radiation environment, at the mine, the concentrator and the processing plant, would be broadly similar to the radiation environments found in similar workplaces at the Ranger uranium mine. This is based on the similar gamma radiation levels, dust activity concentrations and radon decay product concentrations, which have been measured during the exploration work at Nolans Bore. There is also a similar level of thorium in the Nolans Bore deposit as there is uranium in the Ranger deposit.

Gamma dose rates

In general, the in-pit gamma dose rates would be low because the level of contained thorium is low. There would be limited gamma from process material in the concentrator. There would be more significant gamma from higher specific activity thorium hydroxide waste residue in key sections of the processing plant.

Miners

Using the gamma factor and mine average ore grades of about 200 ppm uranium and 2,700 ppm thorium, a gamma dose rate of five µSv/h can be calculated.

Mining would involve an ore to waste ratio of 1:5 and applying this proportionally to the exposure results in approximately a fivefold reduction in average dose rate to approximately one µSv/h. The instrumental gamma surveys over the deposit area gave a ‘global’ dose rate figure of approximately 0.8 µSv/h (Hussey 2016), which is consistent with the average dose rate.

At a nominal dose rate of 1 µSv/h, the annual gamma doses to in-pit on-foot workers such as mine surveyors, geologists and grade control technicians, who spent about 50 per cent of their time in the mine (1,000 hours per year), would be approximately 1.0 mSv/y.

For mine drillers, shielding by their equipment is expected to reduce gamma radiation levels by an estimated 50 per cent, although they would be essentially full time in the pit, therefore the gamma doses would still be approximately 1.0 mSv/y.

In-mine heavy equipment operators are likely to have their gamma doses attenuated by approximately 50 per cent to 70 per cent, due to the mass of equipment between them and the surrounding ground. Therefore, it is expected that their gamma doses would also be approximately 1.0 mSv/y.

Concentrator and processing plant operators

Gamma doses in the concentrator and processing plant are expected to be low because the ore and process materials would be in slurry form and in vessels. Experience at the Olympic Dam, Ranger and Beverley uranium operations shows that processing plant workers generally receive gamma doses of approximately 1.0 mSv/y. This is expected to be the situation at the Nolans concentrator and processing plant.

The assessment noted that there is likely to be an area that would require additional controls due to gamma radiation levels. This is the area producing and handling barren liquor acid neutralisation residue. This residue comprises an iron-thorium hydroxide, and would be of significant specific activity. The equipment surface dose rates in this area would depend on total mass and contained activity, and ingrowth time.

Doses from exposure to radon decay product and thoron decay product

Miners

The radon and thoron concentration in the mine can be estimated using a box model (Cember and Johnson 2009). Modelling was carried out for a ‘worst case’ situation of still air in the mine for a period of two hours.

For radon, the experimentally determined emission rate is 0.4 Bq/m^2/s. For an ore exposure area of 40 ha, the calculated radon concentration is 8 Bq/m^3 after two hours. This equates to a potential alpha energy concentration (PAEC) of approximately 0.04 µJ/m^3. For full time exposure, (2,000 hours per year), the calculated potential dose is 0.11 mSv/y (using the radon decay product dose conversion factors in the Mining Code (ARPANSA 2005)).

For thoron, assuming a mine area of 40 ha and an emission rate of 200 Bq/m^2/s, and completely still air, the equilibrium concentration (which occurs after about ten minutes) is approximately 45 Bq/m^3. For full time exposure, (2,000 hours per year), the calculated potential dose is 0.05mSv/y (using the radon decay product dose conversion factors in the Mining Code (ARPANSA 2005)).

These concentrations are low due to the very large dilution volume of the mine.

Processing plant operators

Metallurgical test work has indicated that isotopes of thorium and radium would accumulate in parts of the processing plant and, as a result, emissions of thoron are conservatively estimated to be approximately 200 MBq/s. As noted, this is also due to the short half-life of thoron, and therefore relatively high activity.

For the purposes of determining an average thoron concentration in the processing plant, a box model was used. It was assumed that a box with dimensions 500 m long by 500 m wide by 50 m high would collect all emissions. This would give an equilibrium thoron concentration of 2 kBq/m^3. Note however that any air movement at all would significantly reduce this by inducing vertical mixing and dilution.

The test work has also indicated that the equilibrium factor, even in stable atmospheric conditions is approximately 0.001 to 0.004. However, the research notes that the equilibrium factor may reach 0.01 and therefore this figure was used to estimate potential doses for processing plant operators.

For an equilibrium thoron concentration of 2 kBq/m^3 and total exposure for 2,000 hours per year, the calculated potential dose is 1.4 mSv/y (using the thoron decay product dose conversion factor from the Mining Code (ARPANSA, 2005)).

See Appendix P for further details on the assessment method.

Doses from Inhalation of long-lived radionuclides in dust

Assessment of occupational dose from inhalation of airborne ore dust is based on the following assumptions:

- Dust concentrations of 1 mg/m^3
- At 10 BqTh/g activity in the ore dust (the 'global average' for Nolans ore) the mass concentration equates to 0.06 α dps/m^3
- A 1:5 ore to waste ratio applied to in-pit dust emissions and
- 2,000 h/y exposure.

This results in an occupational dose of approximately 0.25 mSv/y, without controls.

Summary

A summary of the predicted doses can be seen in Table 12-12

Table 12-12 Summary of worker dose estimates

Worker category	Radiation dose (mSv/y)			
	Gamma	Dust	RnDP/TnDP	Total
Mine on-foot	1.0	0.3	0.2	1.5
Mine heavy equipment operator	1.0	0.3	0.2	1.5
Processing plant operator	1.0	0.3	1.5	2.8

On the basis of modelling and analysis of occupational and environmental baseline data, it is concluded that worker doses at the Nolans operation are expected to be less than 5.0 mSv/y.

12.4.2 Radiation exposure to the public

Gamma radiation

The recognised limit for radiation doses to for members of the public is 1.0 mSv/y.

Gamma radiation exposure to members of the public from sources within the project area is considered to be negligible due to the distance between the sources and the public. The sources of gamma radiation (e.g. ore stockpiles) are well within the project boundary and inaccessible by the public.

Gamma radiation intensity reduces significantly with distance (as one divided by the distance squared when the source is at a distance to be considered to be a point source). The gamma levels at the closest accessible area would be barely detectable and for a full year, the gamma dose is calculated to be less than 1.0 µSv/y.

Airborne dose estimates

Doses from inhalation of both dust and decay products of radon and thoron are based on the estimated annual average concentrations at each of the locations of interest. A summary of the inhalation dose estimates is provided in Table 12-13.

Table 12-13 Public inhalation dose estimates

Location	Total Suspended Particles (TSP) Dust		RnDP/TnDP*	
	U in Dust Dose (mSv/y)	Th in Dust Dose (mSv/y)	RnDP Dose (mSv/y)	TnDP Dose (mSv/y)
Accommodation village (part time)	0.000	0.003	0.001 (0.002)	0.005 (0.012)
Accommodation village (full time)	0.000	0.006	0.001 (0.003)	0.011 (0.026)
Aileron	0.000	0.002	0.000 (0.001)	0.003 (0.008)
Alyuen Community	0.000	0.002	0.001 (0.001)	0.003 (0.007)

* Note that the ICRP has recently recommended an increase in the dose conversion factor for radon decay products (ICRP 2015), although this has yet to be adopted in Australia. The increase is a factor of 2.4 and it is assumed that the factor would be applied to both radon and thoron (both are isotopes of radon). The revised doses can be seen in parentheses in the table.

Ingestion dose estimates

The estimate of the potential annual dose from the ingestion exposure pathway has been modelled for representative persons living at each of the locations of interest. The assessment is conservative based on the assumption is that all food consumed over the year is from the location and this provides a maximum ingestion dose that could be received as a result of operations. The assessment method assumes that dust emissions from the mining operation in the surrounding environment are taken up by plants and animals. Exposure to people occurs when the plants and animals are consumed. The assessment only considers the project originated radionuclides and does not include naturally occurring radionuclides.

The ingestion dose assessment is based on consumption rates as follows:

- 100 kg/y meat (assumed to be 100 kg beef) and
- 90 kg/y vegetable (30 kg/y each of non-leafy, leafy and root vegetables).

Using the standard ICRP ingestion dose conversion factors (ICRP 1995), the human doses can be calculated for residents at the sensitive receptor locations, with results shown in Table 12-14.

Table 12-14 Ingestion dose assessment

Location	Dose (mSv/y)		
	Vegetation Ingestion	Meat Ingestion	Total Ingestion
Accommodation village*	0.027	0.005	0.032
Aileron	0.009	0.002	0.011
Alyuen Community	0.009	0.002	0.011

*Note: For the accommodation village, occupancy time has been assumed to be 8,760 hours per year

Total dose estimates

The total dose estimates at the sensitive receptors are provided in Table 12-15. Note that the doses are based on 100 per cent occupancy (that is 8,760 hours per year) at Aileron, Alyuen and the accommodation village.

Table 12-15 Public total dose estimates

Location	Exposure Pathway Dose (mSv/y)1					
	Dust (U)	Dust (Th)	RnDP	TnDP	Ingestion	Total Dose
Accommodation village	0.000	0.006	0.001 (0.001)	0.011 (0.026)	0.032	0.050 (0.065)
Aileron	0.000	0.002	0.000 (0.001)	0.003 (0.008)	0.011	0.016 (0.025)
Alyuen Community	0.000	0.002	0.001 (0.001)	0.003 (0.007)	0.011	0.017 (0.021)

Note 1: As noted, the gamma dose is negligible (<0.001mSv/y).

Bush tucker assessment

Consumption of local bush tucker in the Nolans region is unlikely to occur in any significant quantities. This is due to the lack of suitable animals and plants in the region which in turn is due to the lack of a reasonable supply of surface water sources.

Nonetheless, a standalone estimate of the potential dose to people living at the sensitive receptor locations from consuming bush tucker from that immediate location has been made. The analysis used conservative assumptions and the dose has been shown to be approximately 0.1 mSv/y at the two closest non-operational receptors, as indicated in Table 12-16.

Table 12-16 Ingestion dose assessment from bush tucker

Location	Dose (mSv/y)		
	Vegetation Ingestion	Meat Ingestion	Total Ingestion
Accommodation village	0.097	0.231	0.329
Aileron	0.032	0.076	0.108
Alyuen Community	0.032	0.076	0.108

Summary

On the basis of modelling and analysis of environmental baseline data, it can be concluded that the Project would result in negligible or minor radiological impacts to the public.

12.4.3 Flora and fauna impact assessment

For the assessment of radiological impacts to flora and fauna, a worst case location of interest has been selected, which is the accommodation village.

For flora and fauna, the assessment method is via the ERICA assessment software (ERICA 2016) which uses changes in the radionuclide concentration of media (such as soil and water) as a result of the operation to determine a risk quotient. The method for determining the change in media concentration is via modelled dust deposition results.

The assessment included two user-defined species with characteristics as follows:

- Wallaby (mass: 15 kilograms, height: 0.7 metres, width: 0.2 metres, length: 0.2 metres)
- Kangaroo (mass 50 kilogram, height 1.5 metres, width 0.75 metres and depth 0.75 metres).

The output of the assessment is shown in Table 12-17 which shows that after 42 years of dust deposition, the 10 µGy/h screening level is not exceeded for any species.

Table 12-17 ERICA assessment output

Species (all ERICA Default Species Unless Noted)	Total Dose Rate (µGy/h)
Amphibian	0.09
Annelid	0.12
Arthropod - detritivorous	0.09
Bird	0.05
Flying insects	0.07
Grasses & Herbs	0.89
Lichen & Bryophytes	2.92
Mammal - large	0.06
Mammal - small-burrowing	0.08
Mollusc - gastropod	0.10

Species (all ERICA Default Species Unless Noted)	Total Dose Rate (µGy/h)
Reptile	0.10
Shrub	0.62
Tree	0.04
Wallaby (user defined)	0.07
Kangaroo (user defined)	0.48

Summary

The ERICA assessment indicates no radiological risk to reference plants and animals from emissions from the Nolans Project. On the basis of modelling and analysis of environmental baseline data, it can be concluded that the Proposal would result in negligible or minor radiological impacts to non-human biota and the environment.

12.4.4 Closure

The closure goals for the Project are to ensure that radiation levels are such that they are consistent with pre-operational levels. Therefore, it is expected that there would be no long term radiological impacts of the project following closure.

To consider future scenarios, Arafura conducted an assessment (using the FEPs methodology (IAEA 2011)) to identify potential failures in the TSF and RSFs (Appendix J). The radiation exposures for the scenarios were then calculated.

The assessment considers a range of features, events and processes that may affect the disposal facilities into the future. The method is widely used for assessing the long term safety of radioactive waste disposal facilities.

The design and closure characteristics of the project's TSF and RSFs were assessed against a set of predefined criteria and potential failure scenarios are developed. Radiological assessments of the possible exposure scenarios were conducted and a summary of the potential doses is shown in Table 12-18

Table 12-18 Summary of assessment on potential doses in event of future failure

Failure scenario	Radiological impact	Comment
RSF liner failure leading to groundwater contamination	Ingestion of 1,000 litres per year of groundwater at Aileron gives an incremental annual dose of approximately 0.016 mSv/y	Radiological impact is negligible
RSF liner failure leading to groundwater contamination	Ingestion of 1,000 litres per year of groundwater at Aileron gives an incremental annual dose of approximately 0.016 mSv/y	Radiological impact is negligible
Erosion of TSF or RSF wall due to excessive rainfall	Loss of containment would result in doses to flora and fauna exceeding the ERICA	Radiological impacts are likely to be minor compared to other impacts of a failure

Failure scenario	Radiological impact	Comment
leading to overtopping and loss of containment	default screening level of 10u Gy/h Full time occupation may result in human doses up to 2.7m Sv/y	
Future drilling into TSF or RSF following closure while conducting exploration	Total occupational dose from gamma and dust for one year is estimated to be 3.2 mSv/y (for TSF drilling) and 4.1 mSv/y (for RSF drilling)	It is unlikely that exploratory drilling would continue for an extended period without workers becoming radiation workers and being monitored
Occupation of rehabilitated TSF and RSF with following cover materials: Regional surface material (natural background) Mine waste rock and regional material (conservative average of 3 Bq/g)	Human dose < 0.5 mSv/y Human dose approximately 2.0 mSv/y	Considered to be consistent with existing natural background levels Considered to be consistent with existing natural background levels

Note that the qualitative risk assessment indicated that it is highly unlikely that the identified failures could occur; however the radiological assessment was conducted on the scenarios to determine the potential doses should the failure occur.

12.5 Mitigation and monitoring

12.5.1 Mitigation

The overall aim is to ensure that radiation is controlled in the design stage of the project using a risk management approach. This means that the design and proposed operation would be reviewed to determine likely radiation sources and levels, and options for control would be identified for these sources. Options would be chosen on the basis of effectiveness, robustness and simplicity, and following the hierarchy of controls as far as possible, with substitution and engineering prioritised before administration and personal protective equipment.

The ALARA principle (doses to be kept As Low As Reasonably Achievable, social and economic circumstances being taken into account), would be followed, both in design and in operations. This would be achieved by implementing a radiation management plan, and by regular senior management review of, and response to, the data generated by ongoing monitoring.

Radiation Management Plan

A draft radiation management plan (RMP) (Appendix X) has been developed which is structured so as to follow closely the headings given in the Mining Code, covering:

- Description (of operations, and of measures for control)
- Demonstrated access to expertise
- Monitoring plan and method for dose assessment
- Provision of appropriate and adequate equipment, staff, facilities and operational procedures

- Details of induction and training
- Details of record keeping and reporting
- Plan for dealing with incidents accidents and emergencies and
- System of periodic assessment and review to achieve continual improvement.

The draft RMP would describe the operations and identify the radiological attributes of the operation and their management.

The record keeping, reporting, dose calculation, and management review processes would be described, together with the means of periodic assessment of effectiveness to achieve continual improvement.

Incident, accident and emergency response

A radiological accidents or emergencies plan would be prepared to identify response requirements for unexpected loss-of-control situations. This would include:

- Advice to first aid / fire-fighting /emergency responders
- Evacuation of non-essential personnel and boundary control
- Stabilisation and containment of the situation
- Dose estimation and controls
- Decontamination and debriefing of affected personnel
- Recovery planning, implementation and reinstitution of control and
- Post recovery investigation, root cause analysis, actions to prevent recurrence, and follow-up counselling.

Unplanned in-plant spillage possibilities would be taken into account in planning, through the provision of bunding to hold 110 per cent of the contents of the largest tank (within the bund) which has lost integrity, or of a tank which may require emergency or planned draining. There would be adequate space for access by clean-up equipment. The design would include concrete flooring and wash to sump pits for pump back to process for spill occurrences.

Radiation control in the mine

The doses to mine workers are expected to be low. Controls to ensure that doses remain low include:

- Restricting access to the main mining areas to ensure that only appropriately trained and qualified personnel are able to access the work areas
- Ensuring that all heavy mining equipment is air conditioned to minimise impacts of dust
- Minimising dust using standard dust suppression techniques (e.g. wetting of materials before handling, wetting of roadways, provision of dust collection systems on drills) and protective measures to reduce subsequent exposure (e.g. use of respiratory protection)
- Monitoring the levels of dust generated during tipping of material onto stockpiles and implementing standard dust control techniques as necessary and
- A separate wash-down pad within the site for vehicles that have come from the mine area.

Radiation control in the processing facilities

For the concentrator and processing plant, the material would be both wet and dry, requiring specific design considerations for dust control and spillage containment. This includes:

- Crushers and conveyor systems fitted with appropriate dust control measures such as dust extraction
- Use of scrubbers or bag houses where appropriate
- Bunding to collect and contain spillages from tanks containing radioactive process slurries, with bunding to capture 110 per cent of the largest tank within the bund in the event of a catastrophic failure
- Pipeline corridors bunded to control spillage of tailings or process residues due to pipeline failures
- Sufficient access and egress for mobile equipment to allow clean-up where there is the possibility for large spillages
- Wash-down water points and hoses supplied for spillage clean-up and
- Procedures to control exposures during the maintenance of the ventilation systems and plant work.

If the monitoring shows that there are elevated levels of dust in the workplace, respiratory protection will be used until a more permanent means to reduce dust is established.

There will be areas in the processing plant that would require installed shielding, with access restrictions. The areas will be defined as control areas, and require work under radiation work permit conditions specific to the task. Spillage will be contained with wash down via concreted sloped flooring and sump.

12.5.2 Monitoring measures

Occupational radiation monitoring

An occupational radiation monitoring program will be developed for operations. The aims of this program are to provide data for the assessment of worker doses and radiation controls for off-site impacts to be effective.

A detailed monitoring plan would be prepared for approval prior to construction commencing. An outline of the elements of such a plan is shown in Table 12-19.

Table 12-19 Outline of proposed occupational radiation monitoring plan

Environmental Pathway	Measurement Method	Location and Frequency
Gamma Radiation	Thermoluminescent dosimeter (TLD) badges issued quarterly	All plant and mine personnel Used for dose data
	Electronic Personal Dosimeters (EPDs) Daily issue as required to potential high dose rate workers	Specific in-pit and maintenance tasks Used for operational control
	Gamma survey with hand held meter Monthly survey	Routine surveys Used for checking effectiveness of controls

Environmental Pathway	Measurement Method	Location and Frequency
Radionuclides in Dust	Personal Air Samplers (PAS) plus drawer assembly count Conducted weekly on representative personnel	Issued to personnel in each workgroup Used for dose estimation
	Locational area samplers Conducted weekly on representative in appropriate work area	Used for investigative purposes
Radon and Thoron Decay Product Concentrations	Grab samples (Borak or Rolle method	Used for investigative purposes and checking effectiveness of controls
	Continuous monitors	Used in workplaces for control and investigation Used for investigative purposes
	Track-etch personal badges	Issued to personnel in each workgroup Used for dose estimation
Surface Contamination	Large-area alpha probe surveys Conducted monthly in appropriate work areas	Surveys in workplaces, offices and lunch rooms Used for investigative purposes and checking effectiveness of controls Used for checking cleanliness of equipment leaving the operational area

In conformity with good ALARA practice, and as a management tool, there would be pre-determined responses at particular trigger levels. These will be defined in consultation with regulators at the time of development and submission for approval of the operational RMP.

Environmental radiation monitoring

In addition to the occupational monitoring program, an environmental radiation monitoring program would occur during operations. The aim of this program is to provide data for the assessment of doses to the public in order to measure any radiological impacts on the off-site environment and to ensure that the radiation controls for off-site impacts are effective.

A detailed environmental monitoring plan would be prepared for approval prior to construction commencing and an outline of the elements of such a plan is shown in Table 12-20.

Table 12-20 Outline of proposed environmental radiation monitoring plan

Environmental Pathway	Measurement Method	Location and Frequency
Direct (external) gamma	Handheld environmental gamma monitor Passive environmental monitors	Annual survey at perimeter of operational area Monitors places at environmental monitoring sites quarterly

Environmental Pathway	Measurement Method	Location and Frequency
Radon and Thoron Gas Concentrations in Air	Passive Environmental Monitors	Monitors places at environmental monitoring sites quarterly
Radon and Thoron Decay Product Concentrations	Real time monitors	Monitor would rotate between off-site locations
Dispersion of dust containing long-lived, alpha-emitting radionuclides	High volume samplers	Monitors would rotate between approved off-site locations
	Dust deposition gauges	Sampling at identified locations
Seepage of contaminated water	Groundwater sampling from monitoring bores	Representative monitoring bores will be sampled annually and analysed for radionuclides
Run off of contaminated water	Surface water sampling	Opportunistic surface water sampling would occur following significant rainfall events
Radionuclides in potable water supplies	Sampling and radiometric analysis	Annually

13

Air quality

13. Air quality

13.1 Introduction

This chapter summarises the baseline and potential air quality impacts arising from the Nolans Project on the surrounding environment and sensitive receptors. A detailed air quality impact assessment report including assumptions is provided in Appendix Q of this EIS.

Section 3.1.11 of the TOR for the project requires the following information in relation to air quality:

- *Inventory (name, composition and quantities) of Project generated air emissions, including from land disturbance, all processing circuits, disposal facilities, vehicles, plants and machinery*
- *Proposed monitoring regime and equipment*
- *Reporting requirements and compliance with relevant health and/or environmental standards*
- *Air quality target thresholds with reference to regulatory industry-standard, health-related safe-limits, or aspirational parameter levels* and
- *Proposed emission control methods, including dust suppression strategies and monitoring of potential dust impacts.*

Section 5.11 of the TOR requires the following environmental objective relating to air quality to be addressed:

- *Sensitive receptors of project generated emissions to air including dust, radon gas and processing plant emissions will be identified and protected from significant impacts.*

This chapter addresses potential impacts on air quality resulting from dust and processing plant emissions for all stages of the project.

Chapter 12 and Appendix P address potential impacts on environmental air quality resulting from radon gas and other radioactive emissions.

13.2 Overview

A summary of the approach to the air quality impact assessment is described below and more detail is provided in Appendix Q.

The pollutants of interest in this assessment are:

- Dust - particulate matter less than 10 microns (µm) in equivalent aerodynamic diameter (PM_{10})
- Total Suspended Particles (TSP)
- Dust deposition
- Sulfur dioxide
- Nitrogen dioxide and
- Carbon monoxide.

Assessment criteria for dust emissions resulting from the Project are summarised in Table 13-1. These criteria are from various jurisdictions around Australia (as indicated in the table) and are considered ‘industry standard’ for the assessment of particulate matter impact.

Table 13-1 Assessment criteria for dusts

Pollutant and jurisdiction	Averaging period	Return interval	Criterion
Total suspended particulates (NSW Approved Methods)	Annual	Maximum	90 µg/m^3
Particulates as PM_{10} (VIC Mining PEM)	24-hours	Maximum	60 µg/m^3 (for area sources)
Particulates as PM_{10} (VIC SEPP (AQM)	1-hour	99.9%ile Design GLC	80 µg/m^3 (for point sources)
Dust deposition (NSW Approved Methods)	Annual	Rolling 12-month average	2.0 g/m^2/month (increment) 4.0 g/m^2/month (maximum)

Site specific meteorological data and background air quality was required for dispersion modelling to predict the impact from mining operations. Baseline monitoring data for ambient dust was collected to provide an indication of ambient conditions (i.e. without mining) at the project site. Baseline data included:

- in-air concentrations collected on site during 2010 and 2011, and
- deposited dust sampling in the area around the proposed mining operations over five years from 2010 to 2015 that conformed to Australian Standards.

Site specific meteorological data was collected including onsite observational data and BoM data from 2011 to 2015 relating to monthly average temperature, relative humidity and wind dispersion

The existing conditions on site are summarised in Section 13.3 below and described in detail in Appendix Q.

13.3 Existing conditions

13.3.1 Climate

Temperatures follow the expected seasonal pattern of cycling between warmer temperatures in the summer (peaking in December-January) and cooler temperatures (lowest in July) in the winter.

Relative humidity was higher in summer and winter, whilst Spring had the lowest humidity. Rainfall followed a seasonal trend of a wet season in the summer to early autumn months, and dry conditions for the rest of the year. The spring months appear to be especially dry, suggesting this the most vulnerable period for poor dust conditions.

The prevailing wind direction is from the south-east with an average wind speed of 2.77 m/s, remaining fairly constant throughout the year. There are also a small proportion of winds from the north-east. In terms of poor dust conditions, the incidence of light winds is important for poor dispersion while the strongest winds create the most wind erosion. This suggests sensitive receptors west and north-west of the site would be the most vulnerable.

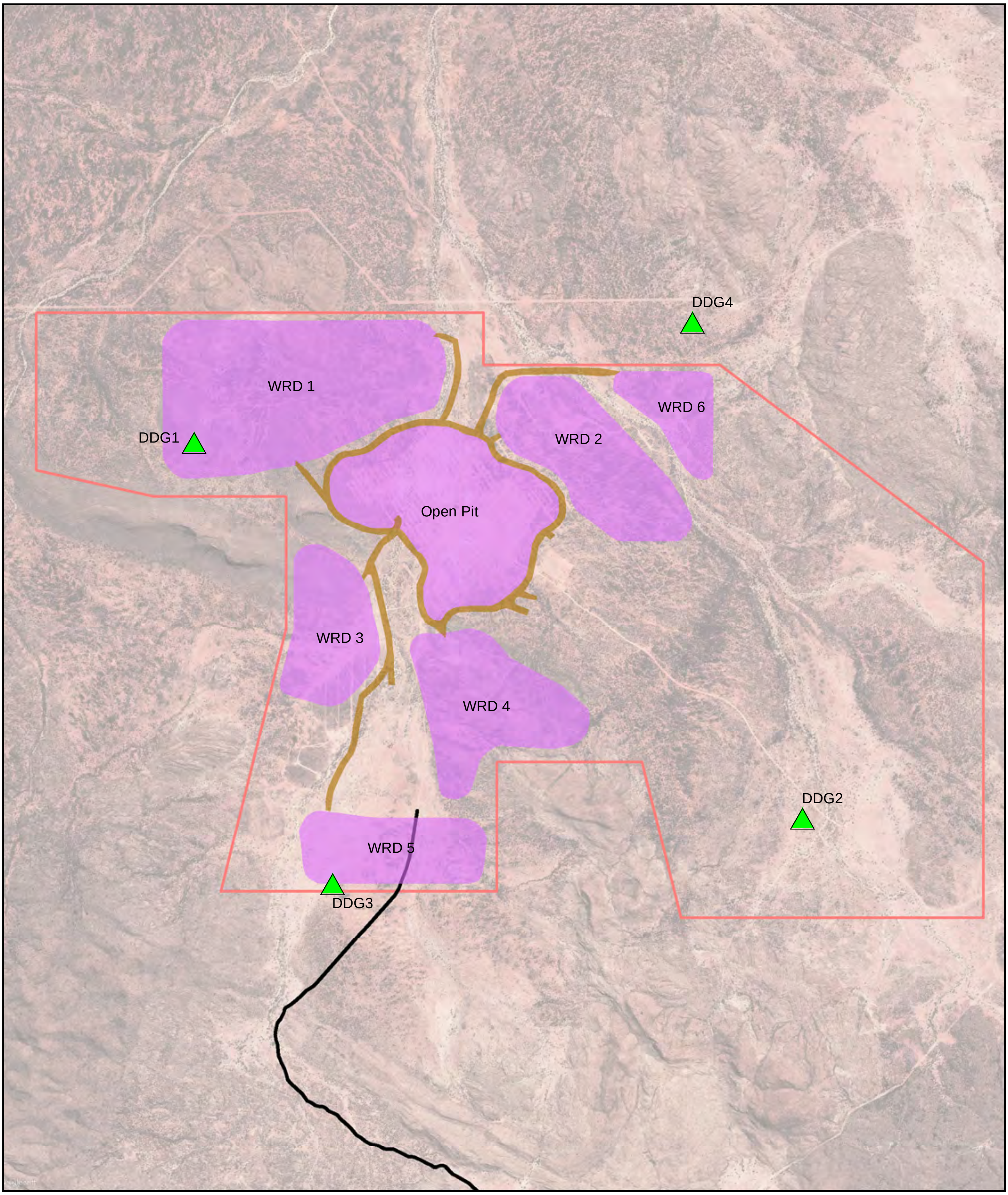
13.3.2 Dust deposition

Dust deposition gauges (DDG) located around the mine site (Figure 13-1) included:

- DDG1 – in the north-west
- DDG2 – in the south east
- DDG3 – in the south west and
- DDG4 - in the north – east.

Fourteen monthly events were recorded where levels of background dust deposition were above the 2.0 g/m^2/month assessment trigger as indicated in Figure 13-2. However, the average across the most continuous monitoring period indicates that all sites were below the annual 2.0 g/m2/month assessment criterion, as summarised in Table 13-2.

Site DDG2 in the southeast quadrant of the mine site, with the lowest value of less than 0.5 g/m^2/month, is the best indicator of the prevailing background dust for the region.



LEGEND

- Dust Deposition Gauge
- Access Road
- Dust Generation Source
- Haul Road
- Mine Site Boundary

1:40,000 @ A4

0 250 500 750 1,000

Metres

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

N

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Nolans Project
Environmental Impact Statement

Job Number	43-22301
Revision	0
Date	13 Apr 2016

Dust deposition gauge locations

Figure 13-1

G:\43\22301\GIS\Maps\4322301_730_DDG.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: 07/03/2016). ARL - Project Areas (2015). GHD - DDG (2016). Created by: CM

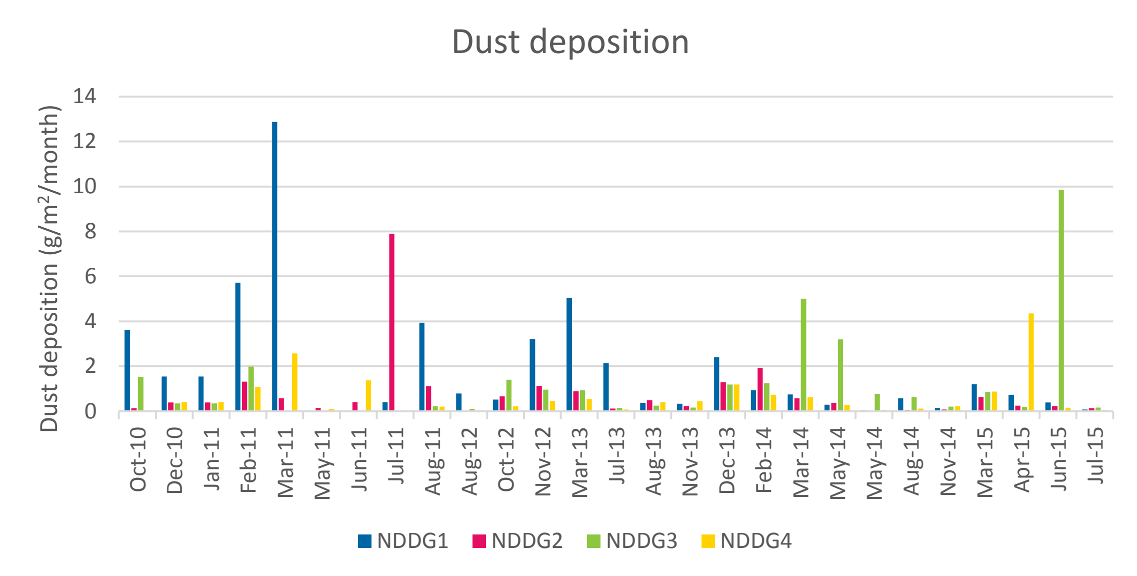


Figure 13-2 Dust deposition from October 2010 to July 2015

Table 13-2 Dust deposition results from October 2010 to July 2015

Monitor	Months where 2.0 g/m²/month is exceeded	12-month average (all data from November 2013 to July 2015 due to ad-hoc gaps in the data dating back to October 2010)
DDG1	8	0.66
DDG2	1	0.49
DDG3	3	1.96
DDG4	2	0.76

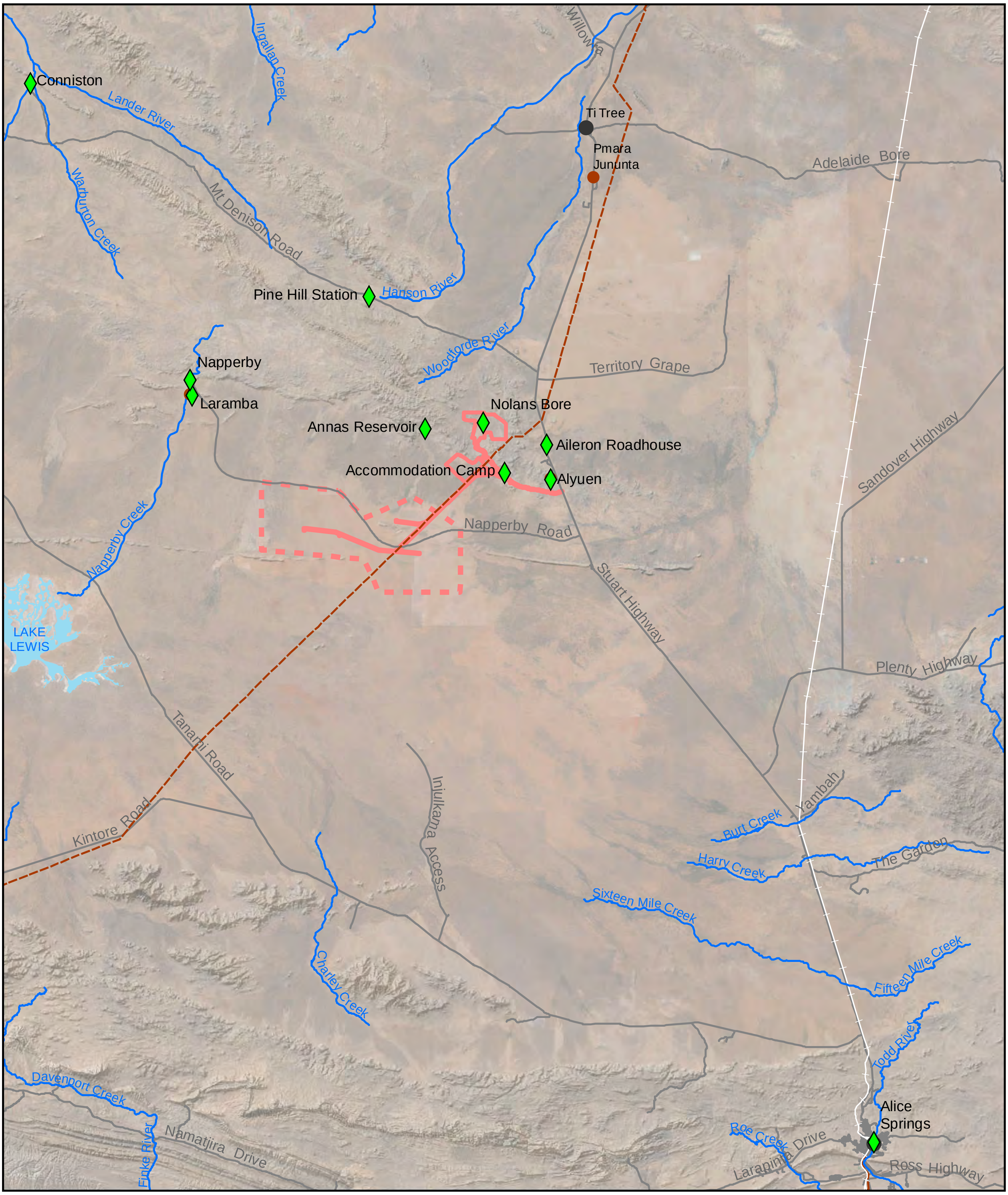
13.3.3 Dust (PM_{10}) monitoring

PM_{10} levels were below the regulation criterion of 60 µg/m³ for the full period monitored although a seasonal increase at the end of summer has been recorded.

Daily averages of PM_{10} were generally less than 20 µg/m³ up until 12 February 2011. After this date, levels increased and appeared to stabilise between 30 and 35 µg/m³. The earlier measurements are more consistent with the accepted non-urban PM_{10} levels found in Australia. The seasonal increase to over 30 µg/m³ is was likely due to local sources at the Aileron Roadhouse, including vehicle and heavy vehicle traffic on dry handstand surfaces, associated with drier and hotter conditions found in summer when during a period of little or no rain occurs.

13.3.4 Sensitive receptors

Communities and family outstations in the surrounding area are considered as sensitive receptors. The location of sensitive receptors considered in the air assessment are indicated in Figure 13-3 and listed in Table 13-3. Note the significant distances, double digit or more in kilometres off-site, from a nominal point of 'Nolans Bore'.



LEGEND

Sensitive receptor	Major Roads	Project Areas
Town	Gas Pipeline	Waterbodies
Community	Major Waterways	

1:900,000 @ A4

0 10 20 30

Kilometres

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

N

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Nolans Project
Environmental Impact Statement

Job Number 43-22301
Revision 0
Date 18 May 2016

Sensitive receptor locations

Figure 13-3

G:\43\22301\GIS\Maps\4322301_731_SensitiveReceptors.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: GA - Roads, Waterways, Placenames, Placenames, Lakes (2015). ESRI - Shaded Relief (2009). Google Earth Pro - Imagery (Date extracted: 15/12/2015). ARL - Project Areas (2015). GHD - Sensitive receptors (2016). Created by: CM

Table 13-3 Sensitive receptor locations

Site	Easting (mE)	Northing (mN)	Distance (km)
Nolans Bore	319070	7501720	0
Accommodation Camp	322800	7493100	9.4
Aileron Roadhouse	330000	7494900	13
Alyuen	330600	7492000	15
Alice Springs	386000	7378600	140
Pine Hill Station	299500	7523300	29
Laramba	269200	7506400	50
Napperby	268900	7509000	51
Conniston	241600	7559800	97
Annas Reservoir	309200	7500600	10

13.4 Emissions inventory

The emissions inventory for the project includes dust generating sources located at the mine site and gaseous generating sources located at the processing site.

13.4.1 Dust generating sources

Dispersion modelling was undertaken in alignment with the seven pit stages (i.e. as separate worst credible scenarios) where the year with the most material being moved about the site, i.e. a 'nominal year' from each pit stage, has been identified to represent the dust emissions from the mine operations over 41-years.

Table 13-4 Pit staging (Mtpa)

Stage[3]	Nominal year	Ore material types[1]		Ore from pit[1, 4]			To WRD[2]	To concentrator	
		0, 1, 2, 3	4, 5, 6	ROM[5]	LTS[6]	Reject[6]		ROM[5]	LTS[6]
1	1	0.36	0.083	0	0.4	0.05	4.4	0	0
2	8	1.8	0.25	0.7	1.26	0.1	2.8	0.71	0
3	10	0.22	0.48	0.36	0.29	0.1	2.3	0.36	0.74
4	11	0.65	0.77	0.73	0.39	0.3	8.6	0.73	0.37
5	20	0.71	1.14	1.0	0.4	0.4	8.1	1.01	0.09
6	31-35	0.53	1.29	0.6	0.3	0.1	8.9	0.62	0.39
7	38	0.24	0.31	0.2	0.3	0.003	9.4	0.25	0.65

Notes:

1. 'Ore material types' add to approximate 'ore from pit' total
2. 'Ore' plus 'waste' is mining rate – initially 5 Mtpa but then 10 Mtpa (year 11 and thereafter)

3. Approximately five haul trucks will be assigned to waste rock movement while four trucks will be used for the ore material – this ratio will change depending on operational requirements.
4. The ore is saturated below a depth of 12 m but will dry out naturally. The stockpiles will be located adjacent to the northern side of the ROM and will be within tramming distance of the front end loaders and can be watered if required to reduce dust emission
5. From the ROM, a front end loader will be used to tram material to the crusher
6. The LTS and Reject pads will be hardstand constructed from benign waste rock.
7. Tailings from the Reject pad will be relocated to a tailing dam east of the concentrator in the form of a liquid-solid. Some recovery of supernatant water is expected.

Mining

Dust generating sources include limited blasting, and use of excavators, dump trucks and dozers to mine the waste rock and ore within the open pit. It is envisaged that the ore will have high moisture content, and dust generation when mining will be lower than mining waste.

Hauling

Overburden and waste material will be transported out of the pit and deposited in purpose constructed WRDs. Ore will be transported out of the pit to the ROM or long term stockpile

Dust suppression for haul roads and operating areas (in pit as well as WRDs and ROM pad) will be required.

Stockpiles and concentrator

Ore will be processed through a plant producing a concentrate and a tailing product. The ROM plant feed will be rehandled once and will be processed soon after being mined. Lower grade material mined during the early years of the Project will be stockpiled off the ROM pad and rehandled twice – once from the Long Term Stockpile to the ROM, and again from the ROM to primary crusher.

After crushing the material will be wet. The crusher will include a dust suppression system.

The RE and phosphate concentrates will be combined as the feed material and the concentrate is pumped in a wet slurry to an intermediate processing site located immediately to the south of the mine lease area.

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

Radiation will be emitted and these were modelled (to assist the Radiation Technical Report at Appendix P) as area sources from stockpile areas (waste rock and tails), processing and beneficiation plants as well as from the open pit, (a tracer methodology was used where Bq/s emissions replaced the usual g/s of air dispersion modelling).

Wind erosion

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

More detailed information regarding dust generating sources is contained in Appendix Q.

13.4.2 Gaseous generating sources

RE intermediate plant

The RE intermediate plant will not be fully enclosed so there will be no need for ventilation stacks. All emissions will have purpose-built scrubbers to mitigate their respective type of emission.

Sulfuric acid plant

It is assumed that the sulfuric acid plant will have a 3/1 Arrangement – i.e. three catalyst beds before intermediate absorber followed by one catalyst bed. This is a standard arrangement for a modern contact sulfuric acid plant for obtaining SO_2 emissions of 4 lb/ST (2 kg/MT) or 99.7% conversion.

Power station

The normal operating natural gas fired generation requirement of approximately 12.5 MW is planned to be 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 were not considered due to a low emissions values and subsequent impacts being insignificant fractions of the respective pollutant criterion.

Key gaseous constituents from these major emitting point source was modelled (Appendix Q) to check compliance to ground level impact. Table 13-5 provides assessment criteria for these gaseous constituents and if plant achieves these compliance limits then other gaseous constituent pollutants will be within limits.

Table 13-5 Assessment criteria for gaseous emissions

Pollutant	Averaging period	Return interval (design GLC)	Criterion
Carbon Monoxide – CO (VIC SEPP (AQM))	1-hour	99.9%ile	29,000 μg/m^3
Nitrogen Dioxide – NO_2 (VIC SEPP (AQM))	1-hour	99.9%ile	190 μg/m^3
Nitrogen Dioxide – NO_2 (NSW Approved Methods)	Annual	Maximum	62 μg/m^3
Sulfur Dioxide – SO_2 (VIC SEPP (AQM))	1-hour	99.9%ile	450 μg/m^3

13.5 Modelled scenarios

Seven scenarios were modelled to represent the dust emissions from mine operations. A summary of these 'nominal year' stages is provided in Table 13-6.

Table 13-6 Summary of modelled mine operational stages uncontrolled wind erosion emissions factors

Stage	Representative Year	ROM Capacity (M-tonnes)	Long term stockpile (LTS) Capacity (M-tonnes)	Reject (M-tonnes)	Mining Rate (M-tonnes)	WRD (M-tonnes)	Uncontrolled PM10 Production Emissions (tonne/y)
1	1	0	0.4	0.05	4.8	4.37	1511
2	8	0.7	1.26	0.1	4.9	2.8	1629
3	10	0.36	0.29	0.1	1.9	2.3	1523
4	11	0.73	0.39	0.3	10	8.6	1759
5	20	1.0	0.4	0.4	10	8.1	1310
6	31-35	0.6	0.3	0.1	10	8.9	2026
7	38	0.2	0.3	0.003	10	9.4	1073

Uncontrolled dust sources

A breakdown of the estimated PM_{10} dust emissions for the stages was assessed, which found that the greatest single source of dust emissions is from haul trucks. The haul trucks are estimated to account for up to 62 per cent of production related PM_{10} emissions (maximum occurring in stage 1).

Dust emissions from haul trucks can be minimised using various control techniques, 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.

Uncontrolled wind erosion

Uncontrolled PM_{10} dust emissions from exposed areas due to wind erosion accounted for approximately 10 per cent of the total dust emissions from the mine, during all stages of its life. As wind erosion has the potential to be the second largest individual dust source, implementing appropriate and effective control measures is important.

13.5.1 Dust control

Control techniques have been assumed and modelled for each of the sources identified at each stage of the mine operations. Some processes have no controls, while other dust sources can be reduced through the application of various measures, including full enclosure if required.

A summary of the controls applied for the air emissions modelling are provided in Table 13-7. Of the identified control measures, these have been applied and used to calculate emissions before and after application. A maximum 74 % reduction in emissions from production activities was found to be achievable with the application of the control measures as summarised in Table 13-8.

Table 13-7 Summary of applied controls (including pit retention)

Activity	Applied controls	Percentage reduction (%)
Graders	Moist soil	50
Excavators/shovels on overburden	None	0
Loading ore to trucks by shovel	None	0
Bulldozers on overburden	None	0
Unpaved haul roads	75% for level 2 watering (> 2 litres/m^2/h)	75
Blasting	None	0
Trucks dumping overburden	None	0
Loading primary crusher	Water Sprays	50
Wind erosion from stockpiles	Water sprays	50
Wind erosion (Active areas)	None	0
Pit Retention	-	50 % for TSP, 5 % for PM10

Table 13-8 Summary of PM_{10} dust emissions with maximum controls applied

Stage	Uncontrolled production emissions (tonne/y)	Controlled production emissions (tonne/y)	Percentage reduction (%)
1	1511	420	72
2	1629	469	71
3	1524	422	72
4	1760	515	71
5	1310	409	69
6	2027	530	74
7	1073	340	68

Pit retention factors

Pit retention control factors have been included. This type of control is a passive control, in that it acts due to the surrounding environment and does not have to be actively applied.

NPI (2012) default pit retention factors are applied to all pit emissions based on the following reduction factors:

- TSP – 50 per cent pit reduction (i.e. 50 % of TSP will not escape the pit) and
- PM_{10} – 5 per cent pit reduction.

Pit retention factors were applied to all dust sources, including wind erosion, from within any operational pit. This includes 50 per cent of the TSP emissions from the following sources:

- Haul roads
- Bulldozers on overburden and
- Graders.

Haul roads

As haul roads have been identified as being responsible for approximately 60 per cent of dust emissions due to active production, special attention has been applied to controlling these emissions. Level 2 watering, as described in NPI (2012) as greater than 2 litre/m^2/h was applied to reduce dust levels for the maximum emissions phase of the mine. Additionally, Arafura has identified the use of a road binding material that is able to achieve an 80 % reduction.

Wind erosion

No controls have been applied to wind erosion from active pits and the large areas of the WRDs.

13.6 Assessment of potential impacts

13.6.1 Mining operations

The pollutants of interest in this assessment of mining operations are:

- Total Suspended Particles (TSP) and
- Particulate matter less than 10 µm in equivalent aerodynamic diameter (EAD) (PM_{10}).

PM_{10}

Appendix Q provides the daily PM_{10} impact contours for each modelled scenario as the 99.9 percentile (Figures B1 to B7). These can be directly compared to the 60 µg/m^3 assessment criterion of Table 13-1.

All of the seven pit stage scenarios modelled show a PM_{10} impact area beyond the mine boundary to the north that extends for 2-4 kilometres. This impact area is across near-mine areas that are devoid of human-related sensitive receptor locations. All other criterion isolines in other directions are generally contained within the mine boundary.

Sensitive receptor locations such as the accommodation village, Aileron Roadhouse, Alyuen and (potentially) Annas Reservoir are well outside the assessment criterion contour. The modelling therefore indicates that human health impact from mining dust is within acceptable levels.

TSP

Appendix Q provides the annual average TSP impact contours (Figures B8 to B14) for each modelled scenario (average for all 8760 hours of 2014). These can be directly compared to the 90 µg/m^3 assessment criterion of Table 13-1.

For annual average TSP, all of the seven pit stage scenarios modelled generally show an impacted area contained within the mine boundary and also well within the PM_{10} daily impact. Pit stages 2 and 4 have marginal extensions of the assessment criterion beyond the northern boundary of the mine operations. This is due to the location of WRD 1 adjacent to the mine boundary and the prevailing south-east quadrant winds for the year. No sensitive receptor location would be adversely impacted.

Dust deposition

Annualised dust deposition impact contours for each modelled scenario are provided in Appendix Q (Figures B15 to B21). These can be directly compared to the 2 g/m^2/month incremental assessment criterion of Table 13-1.

All pit stage scenarios modelled for dust deposition, except stages 5 and 7, show an impacted area just beyond the mine boundary to the north that, however, does not extend as far as the daily PM_{10} impact. Once again, all of these are across near-mine areas that are devoid of sensitive receptors.

All other criterion isolines in other directions are generally contained within the mine boundary with the notable exception of on the western boundary when WRD 3 is in use ('nominal year' stages of 5 and 6).

13.6.2 Gaseous generating sources

Potential emissions considered in this assessment are listed in Table 13-9.

Table 13-9 Gaseous generating sources

Source	Emissions type
Sulfuric acid plant	sulfur dioxide
Power station	nitrogen oxides and carbon monoxide

Sulfur dioxide (SO_2)

The sulfuric acid plant has been assessed for SO_2 emissions and ground level concentrations only, as this is the major component in the tail gas exiting the stack. Appendix Q provides the SO_2 1-hour maximum, as the 99.9 percentile, GLC contours (Figure B22) and the annual average impact contours (Figure B23).

Impacts identified are within two to four kilometres to the south-west and south of the plant, while the annual average reflects the prevailing annual wind pattern with maximum impacts to the north-west. The stack height will be optimised in the design so that the relevant criterion will not be exceeded. At the nearest sensitive receptor location of the accommodation village the assessed impacts are well within the relevant criteria.

Carbon monoxide (CO) and Nitrogen dioxide (NO_2)

The Power Plant has been assessed for CO and NO_2 as a gas fired power plant burns 'cleaner' than for other (solid/liquid) fuels such as coal or diesel. It is universally found that the NO_2 constraint is the pollutant closest to any assessment criterion when the fuel type is natural gas.

Appendix Q provides the CO and NO_2 1-hour maximums, as the 99.9 percentile, GLC contours (Figures B24 and Figure B25, respectively) and the annual average NO_2 impact contours (Figures B26).

As expected, the same pattern as for SO_2 of hourly impacts to the south-west and west with annual impacts to the north-west ensues. In this instance, all of the criteria are at least an order of magnitude below the respective criteria. There is no need to optimise the stack height as a standard 12.5 m high stack is able to achieve the air quality regulated levels. Note that the impact of the power plant exhaust gases is very low at the accommodation village.

13.6.3 Discussion

Key risk pathways associated with air quality have been identified in the risk register for the project (Appendix F). These are discussed below, noting that the key impacts associated with mining dust moving and depositing away from sources, and the gaseous emissions from significant plant (acid and power) are the highest ranked risks. The lower ranked risk pathways were not quantitatively modelled.

- Haulage and transport of material within the Project area, along haul roads within the mine site, and along access tracks; and general site movements over unsealed surfaces resulting in generation and dispersion of particulate or dust
- Wind erosion mobilising dust from exposed surfaces, such as from pits, WRDs, TSFs and RSFs, laydown areas, stockpiles, roads and sites of vegetation clearing
- Drilling, blasting, excavation and materials handling at the mine site during operations results in dispersion of particulates and dust from the mine site (PM_{10})
- Operation of concentrator (comminution and beneficiation circuits) at the mine site, resulting in dispersion of particulate, gas or dust
- Operation of RE processing units, sulfuric acid plant and gas fired generators at the processing site results in dispersion of emissions
- Vehicle emissions and heavy equipment emissions results in impacts to air quality.

The operation of RE processing units (acid plant and power plant) that produce significant amounts of gaseous pollutants have been shown to be well within compliance limits.

As expected, and identified in the risk register, the downwind dispersion of dust has the greatest impact when considering the assessment criteria (Table 13-1, 2.0 g/m^2/month). As usual for large-scale open–pit mining, it is the dust-in-air concentrations rather than the amenity impact of dust deposition that are above nominal compliance limits for greater distances. However, due to the lack of sensitive human receptor locations within the impact zones, the environmental impacts are considered low.

As dust has the greatest potential risk pathway to the air quality values surrounding the mining operations, an audit check on the modelled assessment is recommended as part of ongoing monitoring. A dust monitoring regime is discussed in the next section.

13.7 Mitigation and monitoring

13.7.1 Mitigation and control measures

An Air and Dust Management Plan will be implemented (Appendix X). This will comprise standard dust mitigation measures including:

- Continuous dust monitoring as required during preproduction and construction at site boundary and sensitive receptors

- Chemical or crushed rock treatment of roads (dust suppression for haul roads and operating areas is required to limit dust inhalation by pit personnel and provide safe visual operating conditions. To minimise water usage and subsequent bore field capital and operating costs, a chemical binding agent, would be used in operations)
- Implement road speed limits including lower speeds during highest of wind events
- Use of water sprays on haul roads and unsealed surfaces
- Schedule vehicle and heavy equipment maintenance as per Original Equipment Manufacturer (OEM) requirements
- Diesel fuel to meet Australian standards (for sulfur content)
- Minimise open areas exposed to wind erosion
- Topsoil striping to occur only during suitable wind and weather conditions
- Minimise time between top soil stripping and construction/mining operations. WRD footprints will be developed as required to minimise dust
- Wet ore before crushing and design controls such as use of hooded crusher, covered conveyor and an enclosed HPRG
- Sprays used on ore stockpiles (ROM and Low grade or long term) to limit dust generation
- Once ore is crushed the entire beneficiation process is wet to minimise dust generation
- Dust deposition gauges to monitor and audit the effectiveness of the Air and Dust Management Plan (Appendix X) and
- Controlled emissions release via stack and scrubber.

In the event that exceedances in dust occur implementation of additional management controls would include:

- Operational procedures to include review of weather conditions, wind directions, wind speeds, etc. and stop work if required.

Rehabilitation processes would include:

- Progressive stabilisation of cleared land as activities are completed to limit continued exposure of bare soils and
- Progressive rehabilitation of WRD to minimise exposed material and dust generation.

Plant will be designed to include emission controls (scrubbers) to minimise dispersion of emissions, including potentially:

- Low nitrous oxide burners in design
- Scrubbers installed to control sulfuric acid mist, as required and
- Specific controls for hydrogen flouride emissions

13.7.2 Monitoring

The baseline monitoring data for ambient dust for in-air concentrations and dust deposition would continue through the construction and operation phase of the mine. This would inform future assessments of impacts, based on changes to total dust and anolyte distributions across the network.

Monitoring would conform to Australian Standards and be comparable to US standards as much as is practicable, within the constraints of site access, security, mains power access and ongoing maintenance and servicing requirements.

14

Noise and vibration

14. Noise and vibration

14.1 Introduction

This chapter describes the baseline and potential noise and vibration impacts from the Nolans mine site. A detailed noise and vibration assessment report is provided in Appendix R of this EIS.

The TOR for the preparation of an environmental impact assessment issued by the NT EPA for the Project provided the following environmental objectives in relation to noise and vibration resources:

> *The potential sensitivity of human and biological receptors to noise and vibration and mitigation measures should be discussed in a relevant section of the EIS. The Proponent should address the impact of noise and vibration resulting from the Project on residents and the community in a relevant section of the EIS. The EIS should outline methods for communicating with, and reducing the impact on, residents within the vicinity of Project components or transport corridors who may be adversely affected by the Project.*
>
> *The EIS should outline proposed management to mitigate any identified risks from the Project with regard to noise and vibration emissions. If relevant, the EIS should describe proposed communication with any residents and communities predicted to be impacted by noise and vibration from the Project.*

This chapter addresses the potential noise, airblast and ground borne vibration impacts from the mine site, during the construction and operation of the mine on human and fauna receivers.

14.2 Methodology

A summary of the approach and limitations to the noise and vibration assessment in the study area is summarised below and provided in detail in Appendix R.

Noise criteria applicable for the nearby Project noise sensitive receivers were derived based on the following regulations and guidelines:

- NT EPA Noise guidelines for development sites in the Northern Territory and
- NSW Industrial Noise Policy (NSW EPA 2000).

Aerial photography and a site visit in August 2010 were used to determine the proximity of the closest noise sensitive receivers. The study area for this assessment is defined as including:

- The land within the mine mineral lease boundary
- The Aileron Roadhouse and an access road to the Project site and
- The proposed Nolans Project accommodation village to be located approximately five kilometres south east of the processing plant.

Attended and unattended noise monitoring was conducted in the area surrounding the proposed Project site. The purpose of noise monitoring was to determine the existing noise levels in the area to assist in setting operational noise goals for the Project. Long-term unattended noise monitoring took place between 10 August 2010 and 18 August 2010. Monitoring occurred at the racecourse in the vicinity of the Aileron Roadhouse.

Acoustic modelling was undertaken to predict the effects of industrial (operational) noise generated by the Project. Applicable construction noise criteria for the Project is 48 dB(A)Leq(15min) and applicable operational noise criteria is 35 dB(A)Leq(15min).

14.3 Existing environment

The community of Aileron Roadhouse and Annas Reservoir are identified to be the nearest human sensitive receivers external to the Project site, and are located approximately 13 kilometres to the south east and 10 kilometres west of the mine site respectively. The Nolans Project accommodation village is approximately five kilometres south east of the processing plant.

Long term background noise levels and ambient noise levels were measured by unattended loggers at two locations at Aileron Roadhouse, the nearest identified receiver. A summary of the results is provided in Table 14-1.

Table 14-1 Summary of unattended noise monitoring results dB(A)

Logger	Background LA90 dB(A)1			Ambient LAeq dB(A)2		
	Day (7 am to 6 pm)	Evening (6 pm to 10 pm)	Night (10 pm to 7 am)	Day (7 am to 6 pm)	Evening (6 pm to 10 pm)	Night (10 pm to 7 am)
Logger 1 RBL and Leq Overall	28	27	26	43	36	35
Logger 2 RBL and Leq Overall	27	26	25	45	32	34

Notes

1: Background noise: The underlying level of noise present in the ambient noise, excluding the noise source under investigation, when extraneous noise is removed. This is described using the LA90 descriptor.

2: Ambient noise: The all-encompassing noise associated with a given environment. It is the composite of sounds from many sources, both near and far.

Attended noise monitoring occurred over 15-minute periods at each of the long term monitoring locations. Details of the existing noise environment including noise sources and ambient/background noise levels recorded during these monitoring periods are provided in Table 14-2.

Table 14-2 Attended 15 minute period noise monitoring results

Monitoring location and description	LAeq, 15min	LA90,15min	LA10,15min	Comments on noise environment
Logger 1 Racecourse (near Aileron Roadhouse) 10/8/2010 2.47 pm	38	32	41	Typical rural environment with birds and nearby insects influencing the ambient noise. Wind in foliage was audible. Dam water pump noise was faintly audible during monitoring.
Logger 1 Racecourse (near Aileron Roadhouse) 11/8/2010 8.12 am	39	34	42	Typical rural environment with animals and nearby insects influencing the ambient noise. Wind in foliage was audible. Stuart Highway traffic noise was faintly audible and intermittent during monitoring.
Logger 2 Racecourse (near Aileron Roadhouse) 10/08/2010 3.06 pm	43	34	47	Typical rural environment with birds and nearby insects influencing the ambient noise. Wind in foliage was audible. Dam water pump noise was faintly audible during monitoring.
Logger 2 Racecourse (near Aileron Roadhouse) 11/08/2010 8.29 am	41	33	43	Typical rural environment with birds and nearby insects influencing the ambient noise. Stuart Highway traffic noise was faintly audible and intermittent during monitoring.

Notes:

LAeq(15mins) Equivalent sound pressure level: the steady sound level that, over a 15 minute period, would produce the same energy equivalence as the fluctuating sound level actually occurring.

LA10(15mins) The sound pressure level that is exceeded for 10% of the 15 minute measurement period.

LA90(15mins) The sound pressure level that is exceeded for 90% of the 15 minute measurement period.

The background noise levels are low and typical of a rural environment. Measured background noise levels were below the minimum recommended noise level in the *NSW Industrial Noise Policy* (NSW EPA 2000). Therefore, the minimum background noise levels were adjusted up to the recommended 30 dB(A) LA90 before setting the operational noise criteria.

14.4 Assessment of potential impacts

14.4.1 Construction impacts

Construction noise

Typical noise levels produced by construction plant anticipated to be used on site were sourced from *AS 2436 – 2010 Guide to Noise Control on Construction, Maintenance and Demolition Sites* and from GHD's internal database. Applicable construction noise criteria for the Project is 48 dB(A)$L_{eq(15min)}$.

Received noise produced by anticipated activities during the construction phase are shown in Table 14-3 for a variety of distances, with no noise barriers or acoustic shielding in place and with each plant item operating at full power. The sound pressure levels shown are maximum levels (dB(A) L_w) produced when machinery is operated under full load.

Table 14-3 Predicted construction plant item noise levels (dB(A))

Plant item	dB(A) L_w	Distance of source to receiver (m)							
		50	250	500	750	1000	2000	5000	8000
Crane	105	63	49	43	39	37	31	23	19
Backhoe	104	62	48	42	38	36	30	22	18
Compressor	101	59	45	39	35	33	27	19	15
Concrete pump	108	66	52	46	42	40	34	26	22
Dump truck	117	75	61	55	51	49	43	35	31
Water tanker	107	65	51	45	41	39	33	25	21
Compactor	113	71	57	51	47	45	39	31	27

Noise impact from construction of the proposed Nolans Project is predicted to comply with the adopted criteria at all noise sensitive receivers.

Noise impacts from construction activities will be addressed by the implementation of construction noise mitigation measures in accordance with the noise management plan registered with NT EPA (refer to section 14.5).

Construction vibration

Blasting normally generates the highest levels of ground vibration.

The predicted ground vibrations at various distances are shown in Table 14-4 for typical construction equipment. Given the distance to the nearest receiver from the proposed site is approximately five kilometres, construction vibration is highly unlikely to exceed the human perception criteria.

Table 14-4Predicted construction equipment vibration levels (mm/s PPV)

Plant item [1]	Human perception preferred criteria (maximum criteria)		Predicted ground vibration at given distances				
	Day	Night	10 m	30 m	50 m	100 m	300 m
15 t roller	0.28 (0.56)	0.2 (0.4)	7.5	1.4	0.7	0.2	<0.1
Dozer	0.28 (0.56)	0.2 (0.4)	3.3	0.6	0.3	0.1	<0.1
7 t compactor	0.28 (0.56)	0.2 (0.4)	6.0	1.2	0.5	0.2	<0.1
Rock breaking	0.28 (0.56)	0.2 (0.4)	7	1.3	0.6	0.2	<0.1
Backhoe	0.28 (0.56)	0.2 (0.4)	1	0.2	0.1	<0.1	<0.1

Note 1. NSW RTA Environment noise management manual

Construction blasting

Blasting is likely to be required during construction and operation of the mine. Indicative vibration impact assessment for typical blasting activity have been estimated with consideration to Australian Standard AS 2187.2:2006 *Explosives – Storage and use Part 2: Use of Explosives* (Standards Australia, 2006).

Reductions in levels of ground vibration can be achieved by reducing either the charge mass or increasing the distance to the receptor which reduces the airblast overpressure.

Ground vibration generally attenuates faster than airblast overpressure, and airblast overpressure is generally the critical factor controlling the distance at which blasting can occur without exceeding the human perception preferred criteria. Blasting at distances to receivers of less than 500 m would be restricted by the maximum instantaneous charge.

The maximum construction criteria for airblast overpressure is 115 dB(L) and the ground vibration is 5 mm/s PPV. Airblast overpressure and ground vibration were predicted for a range of charge masses. As shown in Figure 14-1 and Figure 14-2, the airblast overpressure and ground vibration levels for the assessed charge masses are expected to be well under the criteria at the nearest sensitive receiver located approximately five kilometres from the source.

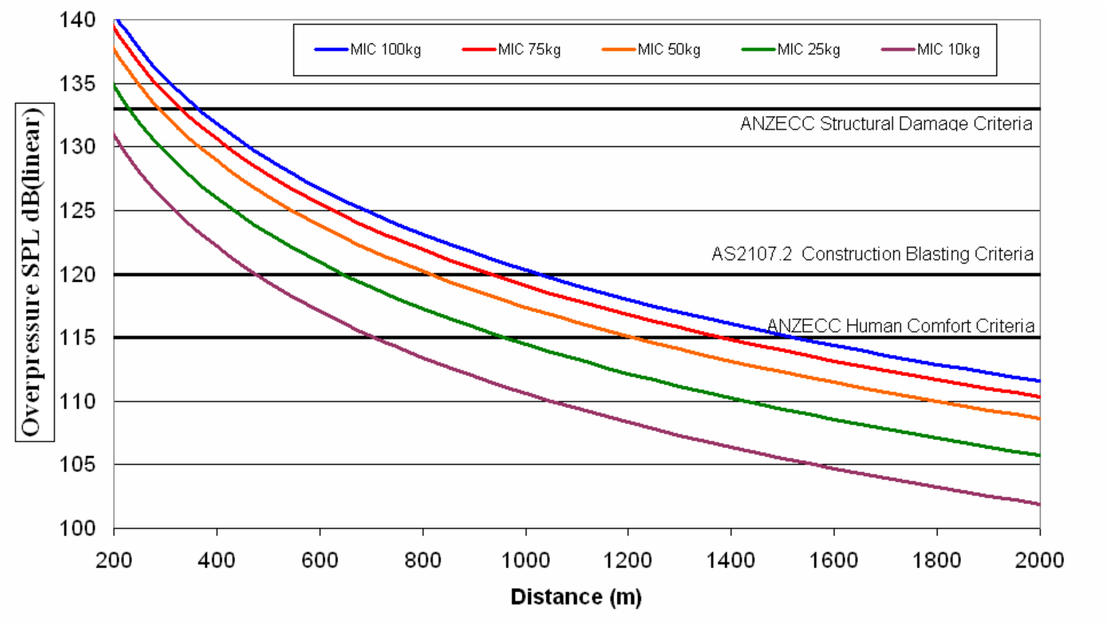


Figure 14-1 Airblast overpressure predictions for different charge masses and distances

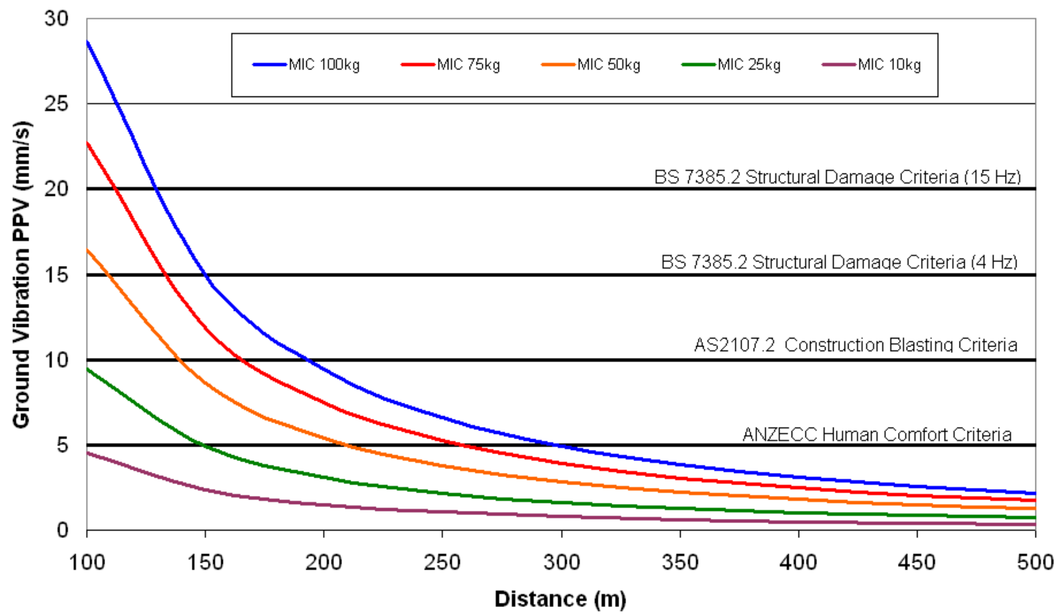


Figure 14-2 Ground vibration predictions for different charge masses and distances

Adverse meteorological conditions such as temperature inversions and wind direction can significantly increase airblast overpressure levels. Temperature inversions are most common during night and early morning periods. This should not affect blasting during the recommended standard hours stipulated in ANZECC.

No details of the blast configuration and design have been supplied at this stage. A maximum instantaneous charge of greater than 100 kg should not be required and a charge of 50 kg or less is likely to be appropriate. As the nearest receiver is greater than five kilometres away, ground vibration from blasting is not predicted to be an issue.

If blasting activity occurs, the design of blast will be determined by the blast contractor and therefore the above information has been assumed for this assessment only in the absence of specific information regarding blasting at the proposed site.

14.4.2 Operational impacts

Operational noise

Due to staging, noise impact will vary over the proposed life of the mine, depending on where machinery is operating. Areas where these changes will occur are the mine pit and the waste rock dump.

Modelled sound power levels for mobile and fixed sources (modelled as point sources) for the proposed mine and processing sites are summarised in Table 14-5. The plant and equipment listed in the table are expected to be the major noise sources from the Project, and that the associated sound power levels (dB(A) L_w) per unit are maximum predicted levels produced when machinery is operating under full load.

Table 14-5 Modelled operational noise sources

Plant item [1]	Make and model	dB(A) Lw per unit	Peak quantity	Modelled source height (m)
Excavator	Hitachi EXI 200	123	3	3
Dump truck	CAT 777F	117	11	4
Dozer	CAT D9T	111	3	3
Grader	CAT 16M	109	2	4
Service truck	MAN 6x6	107	1	3
Water truck	MAN 6x6	107	2	3
Rock breaker	CAT 336DL	118	1	1
Lighting plant	Alight	90	12	1
Front end loader	CAT 990H	112	2	4
Surface crawler drill	Sandvik DP1100	119	6	2
RC drill	Atlas Copco RC127	119	1	2
Dewatering pump	Chesterton	98	3	1
Acid plant compressor	n/a	122	1	5 (ground based plant source) 20 (stack source)

Plant item [1]	Make and model	dB(A) Lw per unit	Peak quantity	Modelled source height (m)
Milling	n/a	118		4
Screener	n/a	111	1	2
Primary crusher	n/a	116	1	3
Secondary crusher	n/a	112	1	3
5 MW gas turbines	n/a	127 (engine noise) 136 (exhaust stack)	3	5 (ground based plant source) 12.5 (stack source)

Note 1. Typical mining equipment noise levels in Table 14-5 have been obtained from:

- Australian Standard AS 2436 – 2010 Guide to Noise Control on Construction, Maintenance and Demolition Sites
- Engineering Noise Control software
- GHD's internal database from past project experience.

The predicted sound pressure levels due to the operation of the Project at nearby noise sensitive receivers are summarised in Table 14-6. Operational noise model contours are also shown graphically in Figure 14-3.

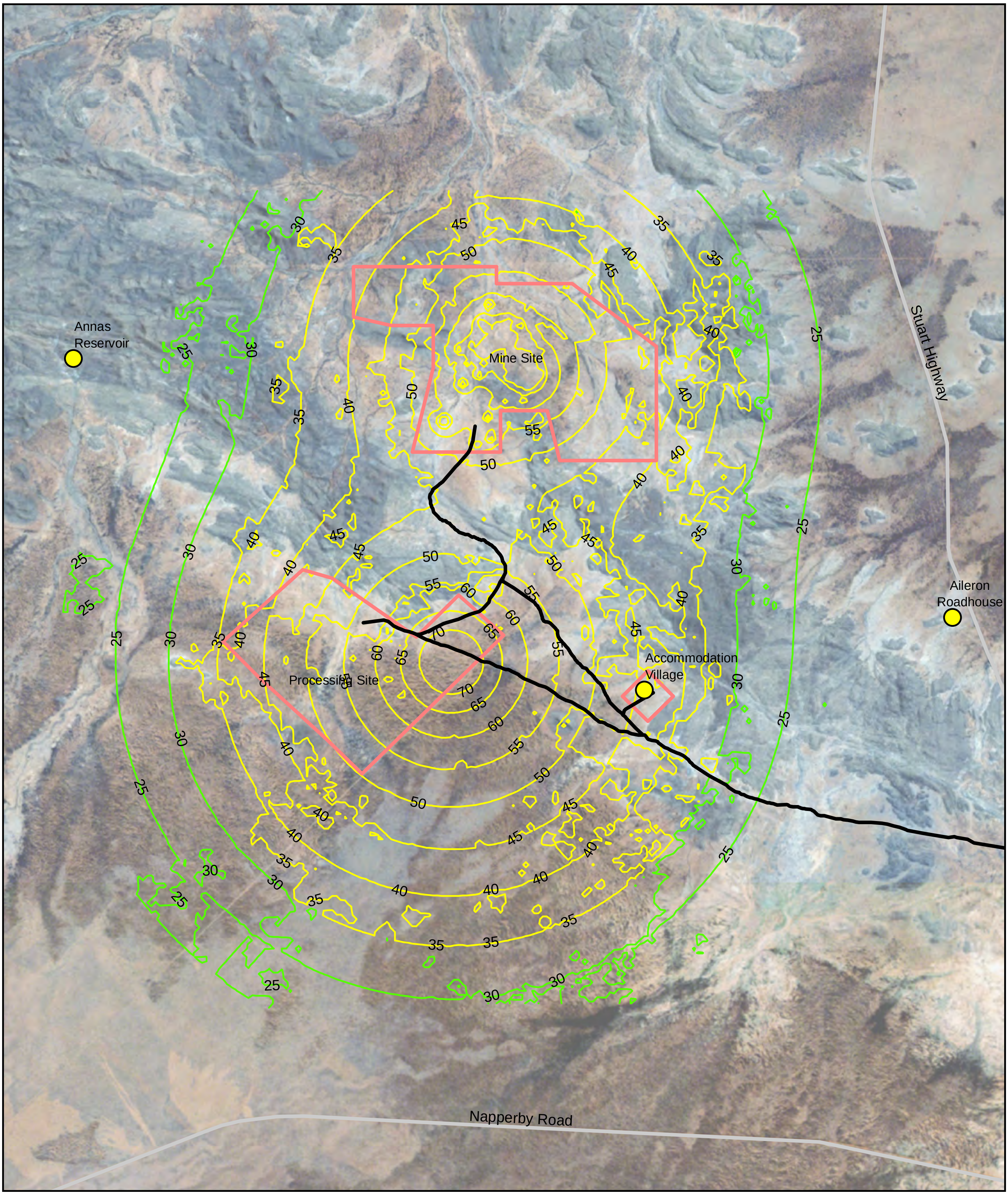
Applicable operational noise criteria for the Project is 35 dB(A)$L_{eq(15min)}$). Table 14-6 shows that the Project's operational noise impact at the Aileron Roadhouse and Annas Reservoir receivers are expected to be below the noise criterion. However, potential 10 dB(A) exceedance is predicted to occur at the Nolans accommodation village receiver, based on the modelling assumptions.

Analysis of predicted dominant noise sources at the Nolans accommodation village receiver, has indicated that the gas turbines stacks at the power station site are the primary contributors. Design of the turbines will include installation of a noise attenuator (silencer or equivalent) at the gas turbine exhaust stacks. The installed attenuator should achieve an overall noise reduction level of 20 dB(A) or more to the stack noise levels. Predicted operational sound pressure levels with the noise attenuator are summarised in Table 14-6 and shown on Figure 14-3.

Table 14-6 Predicted operational sound pressure levels dB(A) at modelled receivers

Nearest sensitive receiver locations [1]	Project noise criteria dB(A) $L_{Aeq(15min)}$	Predicted noise levels dB(A) $L_{Aeq(15min)}$	Comply	Predicted noise levels dB(A) $L_{Aeq(15min)}$ with noise attenuator	Comply with mitigation
Accommodation village	35	45	No	34	Yes
Aileron Roadhouse	35	12	Yes	8	Yes
Annas Reservoir	35	< 5	Yes	13	Yes

Note 1. Prediced for all periods



LEGEND

- Receivers
- Roads
- Access Road

Noise Contours

- < 35 dB(A)LAeq
- >= 35 dB(A)LAeq

- Project Areas

1:125,000 @ A4

0 1 2 3 4

Kilometres

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

N

ARAFURA RESOURCES LIMITED

GHD

Arafura Resources Limited
Nolans Project
Environmental Impact Statement

Predicted operational noise impact contours

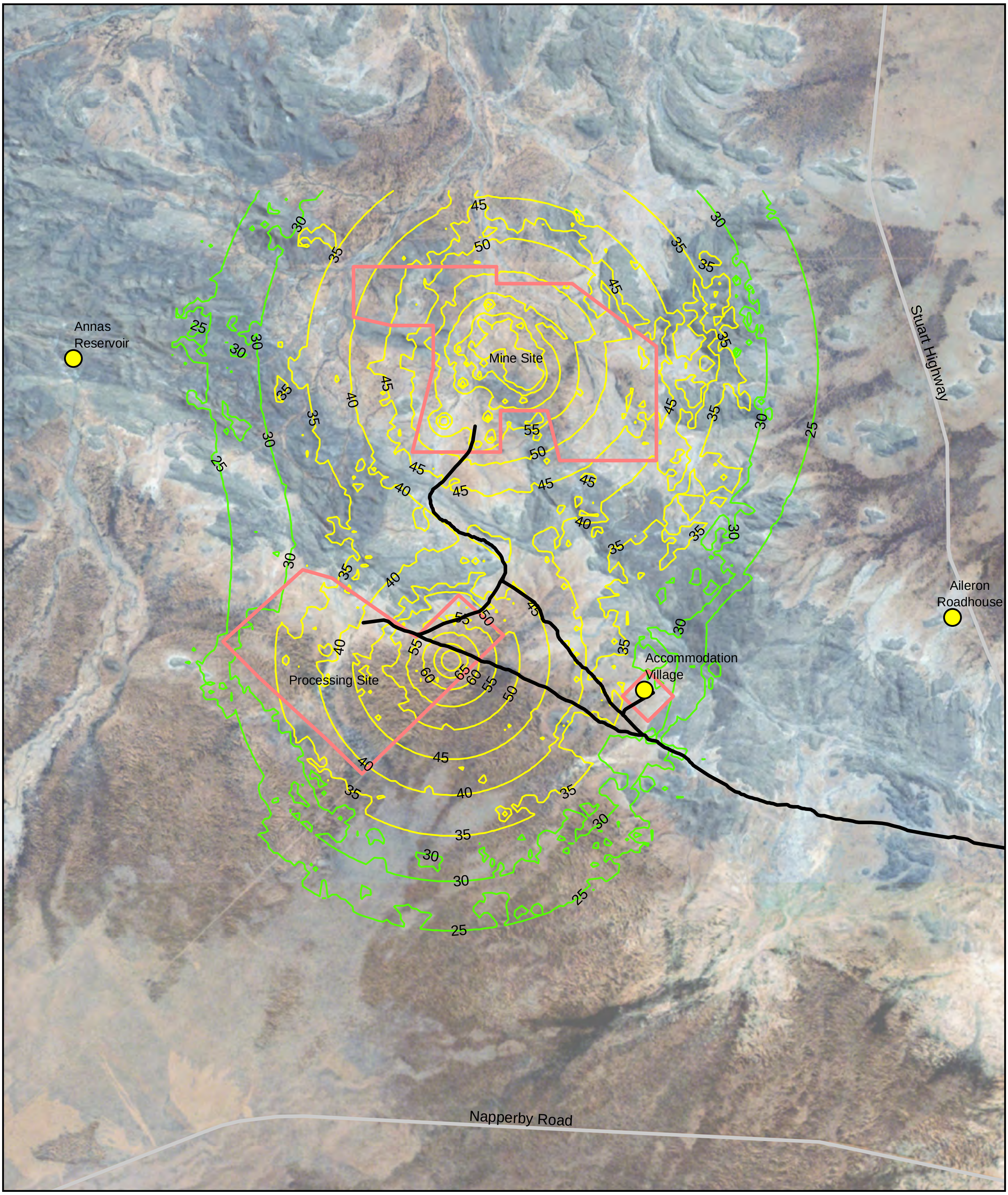
Job Number	43-22301
Revision	0
Date	13 Apr 2016

Figure 14-3

G:\43\22301\GIS\Maps\4322301_034_PredictedOperationalNoiseImpactContour.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: GA - Roads, Waterways, Placenames, Placenames, Lakes (2015). ESRI - Shaded Relief (2009). Google Earth Pro - Imagery (Date extracted: 05/11/2015). ARL - Project Areas (2015). Created by: CM



LEGEND

Receivers
Roads
Access Road

Noise Contours

>=35 dB(A)LAeq
< 35 dB(A)LAeq

Project Areas

1:125,000 @ A4

0 1 2 3 4

Kilometres

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

Arafura Resources Limited
Nolans Project
Environmental Impact Statement

Job Number 43-22301
Revision 0
Date 13 Apr 2016

Predicted operational noise impact contours with noise mitigation measures

Figure 14-4

G:\43\22301\GIS\Maps\4322301_035_PredictedOperationalNoiseImpactContourMitig.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: GA - Roads, Waterways, Placenames, Placenames, Lakes (2015). ESRI - Shaded Relief (2009). Google Earth Pro - Imagery (Date extracted: 05/11/2015). ARL - Project Areas (2015). Created by: CM

Traffic noise

Road access for construction, service, delivery and workforce traffic will be via an upgraded station road in the area, which ultimately connects to Stuart Highway.

The distance between the sealed access road past the Nolans Project accommodation village is approximately 1.5 kilometres. The Aileron Roadhouse is located about 11 kilometres east from the village. Based on typical truck sound power level of 107 dB(A), which equates to a sound pressure level of 35 dB(A) at 1.5 kilometres and 19 dB(A) at 9.5 kilometres. Based on these calculations, as well as the intermittent nature of truck movements, traffic noise along the access road due to the Project is not expected to cause significant impact at the assessed receivers.

Stuart Highway is a government controlled road potentially affected by the Project. The Aileron Roadhouse receiver is located approximately 11 kilometres to the north of the intersection between Nolans site access road and Stuart Highway. Due to this significant distance, Project traffic noise impact along Stuart Highway is not expected to cause significant impact at the Aileron Roadhouse receiver.

Due to substantial distance separation between the unsealed access road and the sensitive receivers, as well as the transport route along Stuart Highway to Alice Springs, traffic noise from the Project is not expected to cause significant impact at the assessed receivers.

Operational blasting

Refer to construction blasting in section 14.4.1.

Construction and operational vibration

All rotating equipment within the Project site will be vibration isolated using vibration isolation mounts, as per manufacturer's recommendations.

Due to the extensive distance (five kilometres or more) from source-to-receiver, it is expected that equipment vibration associated with the operation of the Project would be insignificant at identified nearby sensitive receivers.

Noise impacts on livestock

Sudden noise has the potential to startle or upset domestic livestock and pets. Studies (Heggies 2009) have considered the effect on farm animals to sonic booms (sonic booms being similar in character to airblast from blasting). These studies have indicated that reactions of sheep, horses and cattle to sonic booms (125 dB to 136 dB) were considered slight to mild. Results showed that less than 20 percent of the sonic booms studied caused even a mild reaction on sheep, horses and dairy cattle in temporary cessation of eating, rising of heads and slight startle effects. The total individual milk yield was observed and no affect was found on the overall milk production.

Given these conclusions, it is considered unlikely that the Project will have an adverse effect on livestock in the vicinity of the Project.

Noise impacts on native fauna

Disturbance to fauna associated with generation of unexpected and/or excessive noise and vibration from mining and processing activities during construction can result in the displacement of fauna and disruption to nesting/roosting/foraging behaviour. With mitigation measures in place the risk of impact associated with noise and vibration has been assessed as being low.

Potential noise impacts on fauna is discussed in Chapter 9.

14.5 Mitigation and monitoring

14.5.1 Construction noise

A noise management plan will be prepared and implemented and will include, as a minimum:

- Justification for work on the development site, that is likely to be undertaken outside of the acceptable construction times (between the hours of 7 am and 7 pm Monday to Saturday and/or between the hours of 9 am to 6 pm on a Sunday or public holidays. Whilst acknowledging Arafura's proposed construction hours between 6 am to 6 pm, and the rural location of the project, justification of work outside this period may be required.
- Details and the duration of the activities on the development site likely to cause noise emissions that may exceed the construction noise levels defined in noise guidelines for development sites in the Northern Territory (NT EPA 2013) during a period specified in Clause 10.1
- Details clearly demonstrating how site activity will comply with 'AS 2436 *Guide to Noise and Vibration Control on Construction, Maintenance and Demolition Sites*'
- A complaint management system and documented complaint response procedure
- Documentation on the verifiable consultation and feedback program with occupants of all affected premises, demonstrating that all occupants were provided with advice on dates, times and nature of any potentially noisy and disruptive activity including measures proposed to mitigate such activity as well as noise complaint contact details
- Name of the onsite person who will be responsible for implementing the noise mitigation plan and the name and phone number of the person to whom a complaint may be made about noise emissions from the site

In addition, the following general construction noise mitigation measures will be implemented

- Where possible, activities that could result in elevated noise levels will be scheduled during NT EPA prescribed acceptable construction times (0700 to 1900 hours Monday to Saturday). However, justification of work outside the NT EPA acceptable construction times may be needed (as required in NT EPA guidelines) should this be not possible.
- Review available fixed and mobile equipment fleet and prefer more recent and silenced equipment whenever possible. In any case, all equipment used on site should be in good condition and good working order.
- Plan to use equipment that is fit for the required tasks in terms of power requirements.
- All engine covers should be kept closed while equipment is operating.
- As far as possible, material drop heights into or out of trucks should be minimised.
- Broadband reversing alarms (audible movement alarms) should be used for all site equipment, subject to meeting occupational health and safety requirements.
- All combustion engine plant, such as generators, compressors and welders should be checked to ensure they produce minimal noise.
- Vehicles should be properly serviced. The use of exhaust brakes should be eliminated, where practicable.
- Where practical, machines should be operated at low speed or power and should be switched off when not being used rather than left idling for prolonged periods.

- Machines found to produce excessive noise compared to industry normal standard should be removed from the site or stood down until repairs or modifications can be made.

14.5.2 Operational noise

All mobile equipment will be selected to minimise noise emissions and maintained in good repair. Machines found to produce excessive noise compared to normal industry expectations will be removed from the site or stood down until repairs or modifications can be made. Where required, noise attenuation will be installed in gas turbines exhaust stacks.

Broadband reversing alarms (audible movement alarms) will be used for all site equipment, subject to meeting occupational health and safety requirements.

All site workers will be informed of the potential for noise impacts and encouraged to take practical and reasonable measures to minimise the impact during the course of their activities. These measures will include:

- Where practical, machines will be operated at low speed or power and switched off when not being used rather than left idling for prolonged periods
- Minimising reversing with beepers
- Avoid metal to metal contact on material
- All engine covers will be kept closed while equipment is operating.

Equipment design specifications will include noise limits and associated acoustic attenuation requirements.

Equipment and task specific procedures/work instructions will include noise management, hearing protection training and personal protective equipment instructions.

14.5.3 Vibration

The following construction and operational vibration mitigation measures will be considered to reduce the impact on the surrounding receivers:

- Use of smaller capacity vibratory rollers
- Use of static rollers opposed to vibratory roller/compactors where possible
- Vibration intensive activities to be undertaken during the least sensitive time periods
- Operations sequenced so that vibration intensive activities do not occur simultaneously, where possible.

14.5.4 Blasting mitigation measures

Any blast on site will be designed by a qualified contractor and include consideration of the blasting noise and vibration limits outlined in this report.

15

Socio-economics

15. Socio-economic

15.1 Introduction

This chapter describes the potential social and economic impacts relating to the activities of the Nolans Project.

A social impact assessment report (Michels Warren Munday, 2016) is provided in Appendix S of the EIS. An economic assessment report (ACIL Allen, 2016) is provided in Appendix T.

The TOR for the preparation of an environmental impact assessment issued by the NT EPA for the project provided the following environmental objective in relation to socio-economic issues:

> *To analyse, monitor and manage the intended and unintended social consequences, both positive and negative, of the project and any social change processes.*

This chapter addresses the social and economic impact assessment, as required in the TOR for the project. The level of risk associated with potential impacts to socio-economic values is described in this chapter and assessed in the risk register in Appendix G.

15.2 Methodology

A summary of the approach to socio-economic assessment in the study area is described below and more detail is provided in section 2 of Appendix S and section 1 of Appendix T.

15.2.1 Social impact assessment

The social impact assessment (SIA) considers the social impacts on people, families and communities of the region, including impacts on lifestyles, way of life and livelihoods; including culture, amenity, demographic composition, community cohesion and the potential influence of the project on community infrastructure.

The study covers the planning, construction, operations and mine closure/rehabilitation phases of the project, and considers how impacts will vary over time.

Key tasks in the preparation of the SIA included:

- Identifying a baseline social environment for the study area. This involved:
  - Identification of key areas for study both spatially and socially
  - Desktop review to gather quantitative baseline data, (e.g. 2011 Census data and other publically available social and economic data)
  - Literature review into the history and social context of the region
  - Cross-disciplinary project risk workshop
  - social impact assessment interviews
  - Information gathered from Arafura's community engagement process.
- Analysis and prediction of change resulting from the project against baseline conditions and the consequence of impacts. This involved:
  - Preparation of a risk and opportunity assessment in line with the *AS/NZS 120 31000:2009 risk management –principles and guidelines*, and
  - Grouping of impacts based on *International Association of Impact Assessment* (IAIA), *Social Impact Assessment Principles* (Vanclay, 2003) and *Social Impact Assessment: Guidance for assessing and managing the social impacts of projects* (Vanclay et al, 2015).

The key outcomes of the SIA are:

- Identification and information on community profiles relevant to understanding the people, institutions and communities in which the project will be operating
- A description of how mining and major projects can impact on remote communities and contribute, or otherwise, to their social and economic development
- Potential risks to the communities in the study area
- Identification of potential impacts (positive and negative)
- Identification of measures to enhance positive impacts and mitigate or manage negative impacts
- Provision of indicators for ongoing measurement and reporting against identified impacts.

The study area for the SIA covers communities and people most likely to experience change from the Nolans Project. These impacts would be experienced in different ways, depending on the location, ability to adapt to the impacts and stage of the project. The spatial footprint of the SIA therefore focusses on two key areas of local impact:

- Around the project site: The Aileron and Napperby cattle stations, Aileron Roadhouse, nearby Anmatyerr communities including Alyuen, Laramba and Pmara Jutunta, and the closest service town of Ti Tree
- The main regional centre of Alice Springs, 135 km to the south, which is likely to be a major source of services and supplies, the home base of many workers and a transit centre for fly-in fly-out (FIFO) workers.

The broader regional area includes other nearby cattle stations, Aboriginal communities and important environmental and conservation areas that could be affected by the project's use of water and impact on cultural values (e.g. Annas Reservoir Conservation Reserve, the Ti Tree and Southern Basins).

15.2.2 Economic impact assessment

The economic impact assessment is included in Appendix T. Key tasks included:

- Identifying a baseline economic environment for the study area including:
  - Identification of key areas for study spatially and economically
  - Desktop review to gather quantitative baseline data (e.g. 2011 Census data and other publically available economic data).
- Undertaking economic modelling using Computable General Equilibrium modelling. For this analysis, ACIL Allen's Computable General Equilibrium model, Tasman Global, was used to estimate the impacts of the construction and operation activities associated with the Nolans Project. Three regions were modelled:
  - The Alice Springs region as defined by the Australian Bureau of Statistics SA3 area
  - The Northern Territory
  - Australia.

For the purposes of this study, the life of the project refers to the three years of operation from 2017 to 2019 inclusive plus 20 years of operations from 2020 to 2039 and includes construction and operational phases of the project. Appendix T assumes steady state from year 3 of the project onwards (i.e. 3 years' construction, 2 years ramp up followed by steady state production). After two years ramp up, years 3 to 20 in Appendix T and years 3 to 40 in the EIS, the year in year out figures are constant.

15.3 Existing environment

The following sections describe the existing social and economic baseline identified in the study area, and discuss the relative value of these elements in the regional and wider context.

15.3.1 Regional and local governance

Federal Governance

The key policy directions of the Australian Government relevant to this project are a general emphasis on 'closing the gap' of Indigenous disadvantage and a focus on 'developing the north' by investing in key infrastructure that unlocks investment in mining, agriculture, pastoral properties, horticulture and tourism.

Territory Governance

The Northern Territory Government commissioned a regional infrastructure study and other transport studies and in late 2014 released a *Discussion Draft Northern Territory Economic Development Strategy*. Seven priority opportunities for a prosperous economy were listed in the strategy as being:

- Energy resources
- Minerals
- Tourism
- Agribusiness
- International education and training
- Defence, and
- Supply and service.

Similarly, the Northern Territory Government has a goal of reducing the disadvantage of remote Aboriginal communities through regional economic development, getting children to school and attracting private sector investment into strategic infrastructure that supports a North Australia Development agenda.

The Department of Education has a focus on reform of Indigenous education to support the government's economic development agenda. It is working with major employers to provide links to vocational training, increase the Aboriginal workforce and motivate students to consider careers in, for example, the mining industry. A key goal of government, councils, businesses and mining companies is to employ Aboriginal people.

The key pillars to drive economic growth are identified as resources (oil and gas, and mining), tourism, agriculture, cattle and international education.

Local Governance

Central Desert Regional Council (CDRC) covers an area of about 282,093 km^2 that stretches across the Northern Territory. In the middle is Anmatjere Ward that includes Ti Tree, Yuelamu, Laramba, Engawala, with Willowra and Yuendumu across the boundary with Southern Tanami Ward. The CDRC is a significant employer in smaller communities in the region and employs 74% indigenous staff.

Indigenous Governance

The Central Land Council (CLC) is a Commonwealth statutory authority operating under the *Aboriginal Land Rights (Northern Territory) Act 1976* (ALRA) and a Native Title Representative Body acting under the *Native Title Act 1993* (NTA). CLC represents the interests of native title holders. The CLC covers 780,000 km^2 and 15 language groups in Central Australia. It is governed by a 90-member council, with elected members meeting three times a year in various bush locations.

The CLC negotiates agreements with mining companies on behalf of traditional owners to protect interests in Aboriginal land. Agreements, which can be in the form of an ILUA include compensation payments, employment, training, sacred site protection, environmental protection and cultural awareness. A key focus is ensuring traditional owners are able to make informed decisions about activities such as mining on their country.

While many parts of the Northern Territory are deemed Aboriginal land under ALRA, pastoral properties are covered by the NTA. However, many community living areas (or ‘enhanced NT freehold’) areas have been excised from pastoral leases. Such is the case with the Alyuen and Laramba communities.

15.3.2 Population and communities

The key settlements in the local area of the project (refer Figure 1-6) comprise the following:

- Alice Springs is located 135 km south-southeast of the Nolans site. It has a wide population mix including 43 per cent moving from interstate between 2011 and 2014 and 9.8 per cent coming from overseas; and has a large Aboriginal population. It is a major regional centre with a large service economy.
- Ti Tree is located on the Stuart Highway 193 km north of Alice Springs, 53 km north of the Nolans site and is the closest town to the project. It mainly comprises non-Aboriginal people providing services to nearby Aboriginal communities and outstations and passing travellers.
- Nturiya (Ti Tree Station) is 17 km to the west of Ti Tree on Land Trust land. Access from Nturiya to Ti Tree is via a dirt road and the community is connected to Ti Tree’s electricity and water systems.
- Alyuen (Aileron) is an Anmatjere family outstation, and the closest community to the project (about 15 km). It has a small permanent residential population and is about two kilometres west of the Stuart Highway.
- Aileron Roadhouse is located close to Alyuen outstation. This is an important stop-over for travellers on the Stuart Highway and includes a caravan park, motel style accommodation, a bar, petrol station, and an Aboriginal art shop. It provides services to nearby Aboriginal communities, bus lines and general traffic passing between Alice Springs and Tennant Creek.
- Aileron Station is a 4,078 km^2 cattle station within which nearly the entire footprint of the Nolans Project is contained (with the exception of the western part of the borefield and the proposed Woodforde carbonate quarry). The Aileron homestead and workers’ accommodation are located adjacent to the Aileron Roadhouse. Melbourne-based Aileron Pastoral Holdings Pty Ltd acquired the property in July 2015 from the Dann family.
- Pmara Jutunta (Six Mile) is about nine kilometres south of Ti Tree. Many people commute to Ti Tree for work and school. The community is 46 km north-east of the project and close to the Stuart Highway.

- Laramba is the closest community settlement to the borefield (about 50 km west). It is in the water catchment area for the project's borefield and is home to Anmatjere people, including traditional owners for the land covered by the project. Access to the community is by the Napperby Station road, which runs west from the Stuart Highway. The community is located 83 km from the Stuart Highway turnoff.
- Napperby Station is a 5,356 km^2 cattle station 50 km to the west of the project. This includes a shared borefield area and is close to the Laramba community settlement.
- Pine Hill Station is a 2,686 km^2 cattle station bordering Aileron Station to the north. It hosts the proposed Woodforde carbonate quarry (not the subject of this EIS).
- Pine Hill (Anyumgyumba) family outstation located near the Pine Hill homestead, 35 km west of the Stuart Highway and approximately 30 km north-west of the project. It has a small transient population.
- Willowra is a Warlpiri community. It is located 130 km west of Barrow Creek.
- Wilora is located on Stirling Station, off the Stuart Highway about 30 km south-west of Barrow Creek, and about 60 km north-east of Ti Tree.
- Yuelamu is 230 km north-west of Alice on the old Mt Allen Pastoral lease. Access is from the Tanami Highway.

The population of the Northern Territory as at June 2014 was 245,100, or 1.0% of Australia's population, characterised by high mobility, a large proportion of Aboriginal residents (26.8% in the 2011 Census), younger than the national median age and slightly higher proportion of males.

Territory residents under 15 constitute about 31% of the Aboriginal population, compared with 19% of the non-Aboriginal population. Of the Territory's Aboriginal population, 21.4% lived in remote areas, 28.3% in very remote areas and 20% in outer regional areas as at 30 June 2014.

The Alice Springs Local Government Area had a population of 28,667 in 2014, or 12% of the Territory's population. However, the town acts as a service centre to the Alice Springs Region, or ABS SA3 area, which has a population of 41,700 (including Alice Springs) and covers the bottom half of the Territory.

At the 2011 Census, the number of Alice Springs residents who stated one or both parents were born overseas was almost equal to the number of Aboriginal residents. A key demographic trend is the apparent major increase in overseas migrants moving to Alice Springs from other parts of Australia and overseas since the 2011 Census. A strong growth in migrants coming from new source countries such as India, the Philippines and several countries in Africa has contributed to the stability of population numbers in Alice Springs.

In the broader Central Australian region covered by the SIA, residents are mainly Aboriginal, characterised by a high level of disadvantage across all socioeconomic indicators (ABS 2013, Australian Government 2015). The Central Desert Regional Council area covers more than 28 million square kilometres. The sparsely settled region has a population density of 0.1, is 80% Aboriginal and the Local Government Area had a Socio-economic Relative Disadvantage Index of 557.5% in 2011, the third most disadvantaged local government area in the Northern Territory, compared with a score of 1005.6 for Alice Springs.

The unemployment rate recorded in the 2011 ABS Census for the Central Desert Regional Council was 14.4% while the participation rate was 43.2%, compared with 3.1% unemployment and 61.4% participation for the Alice Springs Local Government Area and 5.3% and 56.5% respectively for the Northern Territory. The unemployment rate for the SA2 Yuendumu-Anmatjere area was 18.1% in 2011.

Table 15-1 provides comparative data of the key communities in or near the project footprint, including data relating to population size and income levels, employment status and other household data.

Table 15-1 Community statistics

2011 population statistics	Alice Springs	Ti Tree	Laramba	Pmara Jutunta (Six mile)	Alyuen	Nturiya (Ti Tree Station)	Willowra	Yuelamu (Mt Allen)	Wilora
Total population in 2011	24,208	123	251	196	25	106	221	207	111
Total population updated (2014)	26,108	143	292				253		
Aboriginal population	4,590(19%)	60 (49.2%)	230 (91.3%)	192	25	95	229	187 (91.7%)	
Median weekly household income	$1,676	$1,281	$987	$1,031		$633	$1,281	$700	
Median weekly rent	$300	$20	$20			$20	$20	$20	
Average vehicles per dwelling	1.7	1.3	1				0.3	0.8	
Median age	33	39	24	22		25	20	28	26
Median age of Aboriginal residents	24	41							
Worked full-time	9,241 (70.8%)	50 (82%)	22 (28.6%)				14 (24.1%)	15 (31.9%	
Worked part-time	2,494 (19.1%)	8 (13.1%)	42 (54.5%)				26 (44.8%)	20 (42.6%),	
Unemployed	404 (3.1%)	0	10 (13%)				15 (25.9%)	3 (6.4%)	
Total dwellings	8,104	56	51	35	6	26	59	55	28
Average people per household	2.6	2.5	4.2	5.9		4.8	5.	4	4.4

Source: ABS (2011): www.censusdata.abs.gov.au, viewed 18 May 2015 (Appendix S)

15.3.3 Employment and economies

Northern Territory

The Northern Territory economy supports a wide range of industries including oil and gas, mining, construction, government and community services and the defence sector. The value of the Gross State Product (GSP) of the Northern Territory is approximately $21.9 billion (2013- 14).

In terms of the value of industry contribution to the Northern Territory GSP in 2013-14:

- The Government sector comprised 18.3 %
- Mining industries, including oil and gas, comprised 13.3 %
- Tourism comprised 4.0%, and
- Agriculture, including pastoral and horticultural sectors, comprised 2.1%.

The dominance of the government sector as a major employer in the Northern Territory is highlighted in the industry of employment results including:

- Nearly 40% of jobs in the Northern Territory are in the government and community services, including the healthcare sector
- Tourism (13% of the workforce)
- Construction (8.2% of total employment)
- Mining (4.3% of the workforce), and
- Agriculture (1.1% of the workforce).

Tourism plays an important role in regional areas such as Central Australia, with a focus on attracting tourists for an experience based on the 'Outback', nature and culture, also generating benefits for small Aboriginal businesses, art shops, retail and dispersion to remote areas.

Mining is a major contributor to the Northern Territory's economy, contributing 13.3 per cent of GSP. In the past year closure of an alumina refinery and several small mines, and exploration activity, consistent with global cyclical trends, is in decline after several years of record expenditure.

The Northern Territory Government is promoting expansion of the horticultural sector, to boost regional growth and jobs, by supporting the availability of land with good soil, a good climate and access to good water. Access to competitively-priced energy is a constraint to growing this industry. The Northern Territory's cattle industry covers 680,000 km^2, or 45 percent of the land. Most cattle properties in Central Australia, including those around the Nolans site, are leasehold and owned by pastoral families, although some have been purchased by interstate or overseas investors.

Alice Springs region

The Alice Springs regional economy is driven by the town of Alice Springs as the major service and supply base for the population of Central Australia and particularly for the surrounding Aboriginal population. It also supports the government services, mining and agricultural industries, the tourism sector, and the Joint Defence Facility at Pine Gap.

Alice Springs supports nearly 2,300 businesses including those in construction, food and accommodation, transport and logistics, and financial services that can support the construction and the operations phases of the Nolans Project.

The Alice Springs SA3 region supports a workforce of around 29,000 people of whom just over 1,100 are currently seeking work. This equates to around 24 percent of the workforce of the Northern Territory and 23 percent of all job seekers in the Northern Territory. The current unemployment rate of the Alice Springs region is comparable with that of the Northern Territory at 3.9 per cent.

15.3.4 Services and infrastructure

Services and community infrastructure in the local area and region around the project is provided primarily by the Northern Territory Government and CDRC, including policing, health and education, municipal services to communities in the local area around the project as well as major infrastructure such as utilities, roads and telecommunications.

Alice Springs

Alice Springs is the largest population centre in Central Australia and is the service centre for the surrounding region. It is serviced by transport infrastructure due to its location on the Stuart Highway and the Adelaide to Darwin railway. The Alice Springs Airport is the major airport for the region providing air links to all mainland capital cities in Australia as well as services to Cairns, Tennant Creek and Uluru.

Alice Springs is a modern town with a good level of social infrastructure, providing the main service and retail opportunities in the region. The town provides the regional hospital and services the health clinics in other smaller settlements. It has ten primary schools, five secondary schools (including boarding for remote students) and tertiary education opportunities. Police, Fire and Emergency Services provide services to the region for incidents beyond the capacity of Ti Tree Police. Alice Springs Town Council provides municipal services in Alice Springs.

Ti Tree

Ti Tree is the service centre for a number of surrounding communities including Alyuen which, along with Laramba and Ti Tree, are the closest settlements to the Nolans Project. The town of Ti Tree contains a limited level of infrastructure however the facilities provided are suitable for a remote town with a small population base of around 120 people. It includes the local office and workshops of CDRC, as well as a school, health centre, police station, women’s shelter, a park, oval, and air strip. Other services include stores, roadhouse and caravan park. Ti Tree is largely surrounded by land owned by an Aboriginal Land Trust.

Key constraints to growth are a lack of housing, insufficient government employee housing to accommodate expanded government services, overcrowding in nearby communities and the need to plan for expanded utilities to support any construction of new houses. There are pressures on the Northern Territory Government to provide more public housing in Ti Tree so people can move to the town from nearby communities.

Laramba

The Aboriginal community of Laramba includes a school, health clinic, stores, a Church, women’s centre, laundry, childcare centre, recreational facilities, and a Community Development Program run by CDRC. There is an air strip half way between Laramba and Napperby Station. Constraints to growth in Laramba include a lack of accommodation for visitors or expanded staffing levels, tenure issues with building additional houses on community living areas, and some issues with water supply. Some community infrastructure improvement projects are ongoing.

Other small communities

Pmara Jutunta (Six Mile) is connected to Ti Tree's power and water supplies. Some houses were upgraded as part of the joint Australian and Northern Territory Governments' Strategic Indigenous Housing and Infrastructure Program, but the level of overcrowding constrains any population increase. The community accesses jobs and community services in Ti Tree, including policing and education. Children commute from Pmara Jutunta to school in Ti Tree by bus and some residents drive to work in Ti Tree.

Nturiya (Ti Tree Station) has few services apart from reticulated water and electricity, a road to Ti Tree and school bus services.

Alyuen community has poor water supply which reportedly led to families moving to Pmara Jutunta (Six Mile) or camps around Ti Tree (Appendix S). The community was connected to a reliable and better quality water supply from the Southern Basins by CDRC in September 2014 following the discovery of water in these basins by Arafura in 2012. Infrastructure improvements currently being considered include a community garden, permanent health facilities for visiting nurses from Ti Tree and a central laundry and ablutions block. Because Alyuen is an outstation, services are provided by CDRC and the NT Department of Community Services.

15.3.5 Health and wellbeing

World Health Organisation (2008) outlines ten key determinants of health comprising:

1. Social gradient: a person's social and economic circumstances
2. Stressful economic and social circumstances mean people are less likely to be healthy and have a long life
3. Early years of life: babies born with low birth weight have a much greater likelihood of developing coronary health disease in adulthood
4. Social exclusion
5. Stress at work: having little control over jobs, limited opportunities to use their skills or in high demand jobs with few rewards
6. Unemployment, job and income insecurity can lead to chronic stress
7. Social support
8. Addiction: misuse of alcohol, drugs and tobacco is harmful to health but is often a response to stressful situations and social breakdown
9. Food security, including good quality and affordable food, and
10. Transport is vitally important to accessing health and other services and, for Aboriginal people, a means to find traditional bush foods and hunting.

Remote Aboriginal Northern Territory communities continue to reflect poorly against these measures, which impact on school attendance and employment outcomes and individual health and wellbeing (Appendix S).

There is a gap between the health status of Aboriginal and non-Aboriginal Territorians, including chronic diseases and mental health. Smoking rates, and alcohol consumption and admissions to hospital for circulatory disease, cancer and injury are higher amongst Aboriginal people than non-Aboriginal people. Aboriginal Territorians comprise 70% of all hospital patients and 93% of renal dialysis patients in the Northern Territory.

Alcohol-related violence is a key issue throughout the Northern Territory although a major government focus is on issues such as alcohol abuse and domestic violence.

The Northern Territory's Centre for Disease Control has reported an increased prevalence of sexually transmitted diseases in Central Australia.

The Department of Transport statistics show that Indigenous people living in remote areas are over-represented in crash statistics.

15.3.6 Natural resources and the environment

Water is a key constraint to population and industrial growth in Central Australia. People place a high value on water and traditionally lived their lives based on its availability, retreating to soaks and permanent water sources during drought. Potential impacts to surface water are discussed within Chapter 7 and Appendix I, and groundwater is discussed in Chapter 8 and Appendix K of this EIS.

There has been an increasing focus on good land management in the Northern Territory, through local Landcare groups (often run by pastoralists) and ranger programs that are a small but significant source of employment for Aboriginal people. For the past fifteen years, the CLC has coordinated ranger groups in Central Australia, with 11 ranger groups now employing about 100 Aboriginal people and helping Aboriginal people work on country. In 2015 the ranger program received $8.8 million in funding.

15.3.7 Culture and way of life

Indigenous heritage

Anmatjere people have strong ties to their land, water and culture and speak their traditional languages at home and traditional owners retain strong cultural authority. Knowledge of special sites on the country around Aileron Station and knowledge about plants, animals and hunting sites in the area has been retained in spite of the many disruptions to traditional Aboriginal culture and way of life due to early pastoral settlement.

European heritage

European heritage is linked to early pastoral settlement, with all cattle properties linked to early settlement and long-standing settler families. Remnants of this early settlement include heritage-listed areas such as the 1929 Aileron Homestead, Ryan Well and Annas Conservation Reserve (outlined above), as well as the old Glen Maggie homestead. Further afield, there are remnants of early settlement in old pastoral homesteads and telegraph stations in the district.

Culture and heritage are covered in more detail in the Indigenous and Historic Cultural Heritage Assessment at Chapter 16.

15.3.8 Human rights

The United Nations Declaration on the Rights of Indigenous Peoples includes the right for Indigenous peoples to be included in impact assessment processes, with a stipulation of 'free, prior and informed consent'. A consequence of this stipulation is the importance of meaningful engagement to ensure Aboriginal people receive information that helps them understand the project, that they are not inhibited from providing feedback and that this is received before any rights are disturbed.

Native title gives traditional owners the right to negotiate an ILUA and compensation, through the CLC, as well as the right to protect sacred and important sites, the right to access for traditional activities such as hunting and the right to have a say on the management or development of land.

An ILUA allows governments, companies and native title holders to negotiate agreements about future developments on the land, including agreement on jobs, compensation and the protection of sacred sites. For example, Anmatyerr families signed an ILUA on the Pine Hill Pastoral Lease in 2007 which provided compensation in the form of a living area, art centre at Mulga Bore and horticultural block. Another ILUA was signed in 2015 as part of the Government's release of two additional horticultural blocks on Pine Hill.

15.4 Assessment of potential impacts

This section examines the potential impacts (described in this case as opportunities and threats) that the project will have on key social and economic features of the existing environment. The level of risk posed to socio-economic factors by each source of impact was assessed using standard qualitative risk assessment procedures, which have been described in Chapter 5 (Risk assessment). The risk associated with each potential impact is detailed in the risk matrix in Appendix G.

15.4.1 Population and communities

The potential improvement in the socio-economic status of residents in Alice Springs and smaller Anmatjere communities, arising from business, employment and training opportunities on the project has the potential to impact positively on the broader population (see also Section 15.4.2).

A long term commitment to the region by the resources sector and supporting businesses will assist in supporting the existing workforce in the region and potentially attracting new workers and their families to the region. Job creation as a result of the Nolans Project could result in new population moving to the area in the form of workers and their immediate families. New population to the area will contribute to the population of the Local Government Area of Alice Springs which currently has a population of 28,667 and is experiencing population growth of around -0.2 per cent per annum for 2013-14.

Negative impacts on community cohesion and community resilience could potentially come from two sources:

- the influx of workers and their families to Alice Springs and the local SA2 region creating tensions with existing communities, relating to employment opportunities, and
- tension that can arise from the distribution of benefits, including wages and royalty payments, particularly management of cash payments.

Local populations not employed by the project may have unmet expectations that could result in tension between the local population, the project and its employees. Perceptions of local traditional owners that outsiders (i.e. from Alice Springs, including Aboriginal people from other places, FIFO workers) are winning the work and taking jobs may result in cultural tensions and resentment.

Royalty payments and increased cash from wages can increase disposable income, with consequential effects on higher levels of alcohol consumption and drug abuse leading to social disruptions within the community. Distribution of benefits payments can be to some family members and not others, which may create inequalities across communities or families. Dependency by local communities on royalties may lead to a decrease in economic participation and a disincentive to work. The increase in disposable incomes may have the potential to lead to anti-social behaviours associated with conflict and alcohol, with decreased feelings of safety, impacts to school / workplace attendance, and increased demand for police and health services.

Additionally, the project may employ people previously volunteering with local organisations or recreational groups. This may lead to a loss of organisers or participants from community groups and sporting clubs due to project roster arrangements, and could result in a decline in quality of some services and viability of local community organisations and sporting clubs, including some voluntary organisations not surviving.

These risks relate to the construction and operational phases of the project. There are high levels of uncertainty about these risks and there may be potential cumulative impacts as a result of other changes in the region, arising from other large resources projects.

15.4.2 Employment and economies

Table 15-2 summarises the key economic assumptions for the project.

Table 15-2 Key economic assumption for Nolans Project

Item	Assumption
Construction period	Three years (36 months)
Peak construction	Year two
Construction workforce	375 FTE
Peak construction workforce	200 FTE
Steady state production year	Year 2022
Steady state production workforce	248 FTE

Source: Appendix T

Project contribution to GSP and real incomes

It is estimated that over the three years of construction, there will be capital expenditure of $1.19 billion on the project of which around $866 million will be spent in Australia. Of this, nearly $145 million will be spent in the Northern Territory including $71 million in the Alice Springs region.

First production is expected in 2020 with steady state production reached around 2022. At steady state, the project will produce around 20,000 tonnes per annum of RE products earning revenue of around $520 million per annum. In steady state operations, there will be expenditure of $90.6 million per annum in Australia including $38 million in the Northern Territory and $18 million in the Alice Springs region.

The potential economic benefits to the Alice Springs region are substantial, with 83 per cent of the total impact on GSP from the Nolans Project accruing to the region. Economic modelling found the contribution to the regional area during construction to be $17 million over the three-year construction period (Appendix T). This is equivalent to an average of $5.6 million per annum.

In steady state operations the potential impact on GSP is expected to be greater than during construction and in the order of an average of $326 million per annum over the modelled period of 20 years. Over the life of the Project, an estimated $6.5 billion will be added to the Gross Product of the Alice Springs region, an average of $284 million per annum (Appendix T). This is a significant positive contribution in an area which has a limited economy based primarily on the delivery of Government Services to the surrounding population.

The project is expected to create an increase in real income of $717 million over the life of the Project including by $282 million in the Alice Springs region. This means that the ability of residents of the Alice Springs region to purchase goods and services and to accumulate wealth will rise by an average of $12 million per annum over the life of the project (Appendix T).

Job creation

The project is expected to create direct employment of 375 full time equivalent workers over the three-year construction period. In steady state operation, the project will employ 250 workers, and is expected to result in the indirect creation of jobs of around 675 full time equivalent job years in the three years of construction. On average this equates to 225 full time equivalent job years in each year of construction (Appendix T).

Indirect employment (i.e. the number of workers employed as a result of the additional expenditure in the economy from the project which generates additional jobs) of around 4,185 full time equivalent job years are expected over the life of the project which amounts to an average of 223 full time equivalent job years per annum. Most of the job creation would occur in the rest of Australia. This is because of the redistribution of profits and taxes from the project are expected to be spread proportionately based on population size in each region of Australia.

There will be significant impacts in the Alice Springs region where an estimated 420 full time equivalent job years will be created over the life of the project. This is equivalent to an average of 18 full time equivalent job years per annum or 1.6 percent of the current number of unemployed people in the Alice Springs region (Appendix T).

New business opportunities

The Nolans Project will provide additional demand for existing goods and services in the region from the direct expenditure by the project and the indirect expenditure as a result of the increased wealth in the region. Arafura has conservatively estimated that the Nolans Project will include expenditure in the Alice Springs region of $71 million in construction and $18 million per annum in steady state operations (Appendix T).

This increase in demand for goods and services may assist in attracting further businesses to the region. The focus for regional development is likely to be the town of Alice Springs, however there is potential for smaller towns and communities to benefit.

Tourism

The room occupancy rate in the Alice Springs tourism region which is dominated by the town of Alice Springs, is currently around 65 per cent which has shown sustained improvement since June 2013 of around 3 percent per annum. Peak occupancy rates tend to be in the months of August, September and October when occupancy rates reached just under 80 percent in 2015 (Tourism NT, 2015). This indicates bed availability of around 500 rooms in the region. The Nolans Project will boost the number of visitors to the area primarily as a result of business related visitors to the project. This will generate additional demand for accommodation in the town of Alice Springs.

Workforce participation

The project represents an opportunity for Aboriginal and non-Aboriginal people from the local region to obtain work experience in the mining and minerals processing industry in which few people are currently employed (Appendix T). In doing so, it provides them with the skills and experience to gain work on other mining and construction projects that are operating or planned. There are challenges however, including the following:

- how to maximise local employment without removing workers from other employers
- how to engage a large source of unemployed Aboriginal people into a productive workforce, avoiding saturation of communities with mining workers at peak periods, while encouraging families to move and become part of the community longer-term, and
- boosting local economies in a sustainable way so the benefits last beyond the life of a project.

While the potential economic benefits are substantial, the potential impacts from sourcing employees from local communities are highly uncertain given the available work-ready labour pool relative to the project's labour needs, particularly during construction.

Recruitment of personnel for the project may source staff from existing jobs in Central Australia, resulting in employment losses to existing local businesses (e.g. retail, hospitality, council), attracted by the higher wages available in mining and minerals processing. This may impact at least in the short term, on delivery of services to some private businesses, government and local government, as organisations source new staff.

Key impacts for the CDRC are expected to be localised loss of talent around Ti Tree, in particular with Aboriginal workers. There is a smaller pool of workers to draw from, and any Indigenous participation in the project's workforce may impact on local services, which may take a medium-term period from which to recover. Employers, including Government, may lose staff to the project and have to backfill with less qualified or trained staff or struggle.

Local business

Arafura expects that the project will create opportunities for Alice Springs-based providers of services and supply during its construction and operational phases. The company intends to adopt procurement policies and processes that will encourage and assist local business to participate in the project. Use of local contractors and businesses by the project may result in some short-term reduction in business capacity in the local area. This impact is anticipated to be highest during the project's construction period when there will be short term demand for a range of contractor services.

Local businesses that cannot meet the company's prequalification requirements may not win work on the project, resulting in unmet expectations and negativity towards the project (including project employees). This may result in some dissatisfaction across the broader Central Australian business community.

The company will encourage project personnel to relocate to the Alice Springs area. The economic and social impact on the region, should this occur in reasonable numbers, is expected to be positive. However, a substantial influx of people may result in localised inflationary pressure on goods and services, including on private housing, rent, trades and childcare. There may also be additional pressure on government and NGOs to meet the possible shortfall in services.

Arafura will continue its policy of stakeholder engagement to communicate the project's timeframes and program of works to local business, community and other stakeholders. This should result in people having sufficient time to plan for the project's arrival. Nevertheless, it is possible that local businesses may over-extend and invest unsustainably in staff and equipment, particularly during the construction period.

Indirect opportunities

Increase in local employment opportunities may lead to positive impacts of higher levels of employment, economic participation, improved education outcomes and reduced levels of disadvantage. This may result in higher incomes for families reducing social disadvantages. There may also be increased interest in private ownership of houses, which in turn reduces pressure on public housing. Associated indirect impacts may have a positive effect on other sectors, such as retail, goods, services and hospitality due to increased wealth in the community and increase the capacity of local businesses. This may result in long-term growth in business capacity of the region. Employment opportunities from the project may also lead to a general up skilling of the workforce, increasing long-term employability of the workforce.

15.4.3 Services and infrastructure

The project will potentially create the opportunity for improved infrastructure that benefits local communities, particularly if the combination of the Nolans Project and horticultural expansion prompt the growth of Ti Tree as a regional economic hub. Benefits could include better telecommunications and essential services.

Infrastructure investment or equipment associated with the project, such as road upgrades, communications networks and power supply would provide indirect benefits for local communities. Improved access to services and improved communications, with access to better regional infrastructure, may indirectly encourage other economic activity to the region, e.g. horticultural activities.

The predicted impact on services is uncertain, driven as it is, by employment and workforce issues. However, it is likely that both Alice Springs and nearby communities can absorb the proposed project workforce without a great impact on existing services such as health, housing and emergency services, particularly as the FIFO/BIBO workforce is planned to be largely accommodated at an onsite workers' village.

Cumulative impacts however from other potential developments / projects operating at the same time could lead to pressures on scarce public housing (through inflationary impacts on the private housing market) and on the availability and affordability of private housing.

Additionally, a return of people to local communities (such as the Anmatjere people) to take up employment opportunities with or resulting from the project may lead to pressures on local community housing and create a demand for more private housing and community infrastructure in Ti Tree. Population mobility to the smaller communities could put pressure on housing and community infrastructure at these locations. This may result also in a higher demand for police, health, emergency and education services with potentially adverse impacts to service delivery.

15.4.4 Health and wellbeing

The project has the potential to result in reduced substance abuse, and increased health and wellbeing outcomes in Aboriginal and non-Aboriginal communities, due to employment and training opportunities and access to higher wages.

On the other hand, the project has the potential to create additional substance abuse and mental health issues associated with the high wages and living away from home conditions prevalent in the resources industry.

Additional health issues associated with the project include real or perceived potential impacts such as dispersion or storage of radioactive materials, transport of dangerous goods, dispersion of dust, tailings dam failure, waste storage, contamination of water and spills. This may result in local communities opposing the project, leading to project delays or withdrawal.

15.4.5 Natural resources and the environment

The project may enhance opportunities for the existing Aboriginal Ranger program to become involved in long-term land management projects associated with the Nolans Project. There is also an opportunity for active land management of landscape-scale threatening processes (e.g. management of feral animals and fire).

Conversely, there is the potential for the project to impact negatively on ecological functioning.

While actual loss of access to and enjoyment of the natural environment is predicted to be low, there may be negative perceptions of changes to the landscape because of the scale of the project.

The project may be perceived by adjacent land users (including Aileron and nearby stations) to be incompatible with their operations, including impacting on the quality and marketability of farming products, leading to tensions and potential for reputational impacts to the project. This may result in adverse perception of the project within the broader community.

Concerns about cumulative environmental impacts on the project are predicted to be low but cumulative industrial and mining development in Central Australia is likely to be perceived to impacting on the environment, in particular water supplies.

15.4.6 Culture and way of life

The project has the potential to enhance existing cultural programs in the region through added wealth in the broader community and through the development of a larger population to support such programs.

The project may have an impact on Aboriginal lifestyles and culture if the project challenges cultural authority or contributes to the breakdown of traditional law and cultural practices (e.g. though the removal of or damage to sacred sites). Project activities may result in perceptions by pastoralists, recreational users and traditional owners of a changed landscape and restricted access to traditional lands and conservation zones leading to concerns relating to cultural authority and connections. The likelihood that this will occur is low.

The project could impact on the broader lifestyle and culture of the region if mining and mineral processing replaces pastoralism as the predominant land use activity and brings in workers and their families who have no connection to or appreciation of the area's strong pastoral way of life. However, this likelihood is also considered as low.

The project may accelerate cultural change of local Aboriginal communities, including reduced strength of culture, language and customs. This may lead to a reduction in cohesion of community, including decline in respect for traditional law and authority from those people with increased contact with the project.

15.4.7 Human rights

In general, it is not envisaged that the project would have an impact on human rights, which are protected by a number of statutes and native title organisations, including the CLC.

The key impacts on rights are more likely to be unintended, such as racism experienced by workers. This could lead to reduced workforce participation in the project.

15.5 Mitigation and monitoring

The following mitigation measures will be implemented to address potential impacts arising from the Nolans Project.

15.5.1 Pre-construction and planning controls

A Social Impact Management Plan (SIMP, Appendix X) will be implemented prior to construction commencing, including:

- Agreements that, where practicable, provide continued access to traditional lands including access for cultural activities
- If requested, annual visits to the site by traditional owner groups
- Consider the demand and supply for goods and services expected for the project
- Identify measures to manage the impacts on local services, e.g. by providing additional temporary accommodation

- Community Reference Group to identify issues, and
- Measures will be implemented to minimise a reduction in community volunteering. This will include community investment programs for workers which may include volunteering and a volunteer program for staff.

A workforce plan will be prepared to prevent breaches in labour law, equitable opportunities, and women in the workforce. This will include:

- Performance criteria mandated in contracts to ensure adherence to human rights and labour requirements
- Collaboration with the CLC with the intention of achieving equitable treatment and employment of a community liaison officer to interface with the community
- Mentoring and support provided so any incidents are raised and resolved
- Key Performance Indicators (KPIs) around inclusion of locally based employees and indigenous employment program
- KPIs for contractors regarding indigenous and local employment
- Collaboration with relevant recruitment providers to increase the available local labour pool, e.g. through shared planning and training programs, and
- Consider using the "Sentenced to a Job" program to supplement the project's workforce.

The workforce plan would contain a program for work-readiness and training. This will include:

- Engaging with Community Reference Group and local education providers to develop strategies to get members of the local community work-ready
- Ensuring contractors have a commitment to Aboriginal participation, and
- Providing information about company expectations and the types and range of jobs available, including opportunities for women.

A pre-construction business management program will be established for engagement and training of local businesses to identify potential demand for goods and services. This will include:

- Providing advice on planning and timeframes of contracts available
- Monitoring the use of local resources and external providers to reduce impact on other businesses, if practicable
- Procurement policies to account for a company's size and ability to sustain growth, and
- Collaborating with the Northern Territory Government, ICN and Chamber of Commerce to prepare local businesses for opportunities.

A communication strategy will be implemented to alleviate community concerns relating to health and environmental impact. This will include:

- Provision of fact sheets and community information taking into account culturally appropriate formats for material
- Community information sessions to understand community concerns and provide information
- Community Reference Groups to respond to community concerns, and
- Consultation with adjacent land users to provide information on the project, potential effects and proposed management measures.

An exclusion zone around key operational areas of the project will be established to exclude pastoral activity thereby mitigating potential for adverse impact on pastoral operations.

Transparent monitoring and availability of results, including regular publishing of baseline data and operational data will be provided to regulators. This will include engagement with the Australian Government's Office of the Supervising Scientist and independent radiation experts.

Regular liaison with the three levels of Government will be undertaken on a regional approach to infrastructure development and on shared planning to optimise the potential for the project to supply local communities.

15.5.2 Operation

All distribution of community benefit payments will be managed either via the CLC or through an agreed trustee arrangement with the aim of an equitable distribution of benefits.

A Community Relations Officer will work with communities and agencies to address concerns relating to distribution and management of economic benefits.

Consideration will be given to planning a negotiated community benefits package with less dependence on cash payments.

Employment training programs will include life skill training including money management topics.

Strict policies about worker behaviour and drug and alcohol programs will be established for the project workplace. This will include restrictions on leaving site during roster thereby reducing potential for negative impact of project personnel on communities.

Contract and service opportunities will be packaged to enable local businesses to be competitive and prime contractors may be required to provide opportunities to local business in their supply chains. Local procurement strategies will be managed to increase the number of successful businesses, e.g. establishing consortia and partnerships.

The success of local businesses involvement with the project will be communicated.

A short-term accommodation strategy will be prepared to manage the capacity of local hotels and likely project demand. This strategy will include monitoring of potential displacement and cost pressures on Alice Springs hotels, matching rosters and transport from site to flight schedules, and providing temporary accommodation if necessary.

Onsite project facilities will include medical facilities for staff. Other health support initiatives will include mediation/counselling provided by off-site trained specialists and workplace training and awareness programs.

The Cultural and Heritage Management Plan (Appendix X) will include cross-cultural awareness programs and a cultural induction program will be mandatory for all employees and contractors.

16

Heritage

16. Heritage

16.1 Introduction

This chapter describes the Aboriginal and historic (non-Aboriginal) cultural heritage values of the study area, and discusses previously recorded or newly identified Aboriginal and historic heritage sites in the vicinity of the Nolans site. This chapter also addresses the potential impacts on Aboriginal and historic heritage arising from project activities, and provides mitigation measures to minimise the direct and indirect impact of proposed mine construction and operation.

A detailed Aboriginal and Historic Cultural Heritage Assessment has been completed for the project and is provided in Appendix U for review by the NT EPA. The report is not however, included in any public release of the EIS, for reason of respecting cultural sensitivity following consultation with traditional owners.

A Cultural Heritage Management Plan is included as a sub plan in the EMP, provided in Appendix X.

Section 5.10 of the TOR for the preparation of an environmental impact assessment issued by the NT EPA for the Project provided the following environmental objective in relation to cultural heritage:

> *Places and items with historic and/or cultural heritage values protected under the Heritage Act, the Northern Territory Aboriginal Sacred Sites Act or any other relevant Territory or Commonwealth legislation, will be identified and those values protected.*

The term 'cultural heritage' includes, very broadly, all places and values of archaeological, traditional, historical or contemporary significance. Cultural heritage assessments investigate the value or significance of particular items, sites and places to the whole or particular sections of society and are one of the steps in the process of management and conservation of cultural heritage values. The cultural heritage assessment process operates on the basis that Aboriginal and non-Aboriginal cultural heritage should be conserved and protected and that project proponents have a statutory responsibility to protect such values.

16.2 Methodology

16.2.1 Review of background data

A review of previous reports and assessments was undertaken including:

- Review of the current Aboriginal Areas Protection Authority (AAPA) Authority Certificate(s) for the subject land to identify known sacred sites
- Review of databases in May 2015 to identify known Indigenous and non-Indigenous historic sites, places or objects of heritage value. Databases included:
  - Northern Territory Heritage Register
  - National Native Title Tribunal Register
  - The *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) National Heritage List and Commonwealth Heritage List.

16.2.2 Review of the environmental, ethnographic and archaeological context of the subject land

A review of the environmental, ethnographic and archaeological context of the subject land was undertaken to identify the potential for any unknown objects and/or places of significance. The following was reviewed:

- Environmental characteristics - such as drainage lines, topography and geology to provide insight into how people used land in the past, and establish a context for identifying the archaeological potential of the area. It also assists to explain why certain historical events may have occurred and why certain historical themes may apply or dominate in a particular area.
- Ethnographic and historical literature - to provide insight into history of use and occupation of the study area based on documentary evidence and early ethnographic records. It also identified factors that may have affected archaeological site survival and any historical archaeological relics that may survive in the study area.
- The archaeological context - including the previously documented known places and objects, locally and regionally, that have been recorded by other archaeologists.

16.2.3 Field survey

Cultural heritage survey was undertaken by Daryl Wesley and Ngaire Richards (Heritage Advisors) from 27 April to 5 May 2015 to:

- confirm the location of previously recorded sites (e.g. mine site survey in 2006, 2012)
- record any additional Aboriginal and historic sites, places or objects identified within the study area
- identify any additional areas of archaeological potential.

The survey comprised sampling within the footprint of proposed key infrastructure (processing site, accommodation village, borefield, access roads, water supply and power distribution lines).

Areas of ground exposure were examined for archaeological evidence such as stone artefacts, mature trees were examined for Aboriginal cultural scarring, and rock outcrops were examined for the presence of rockshelters and evidence of quarrying and rock art (pertroglyphs). Creek gullies were also examined to document soil profiles, soil disturbance, erosion and potential for sub-surface archaeological deposits.

The sampling program considered the various land system units of the study area such as geomorphology, landform and vegetation, as well as available access.

The combined length of the pedestrian and vehicular archaeological survey transects totalled 170 km. Vehicular transects consisted of 107 km of survey, with pedestrian survey transects covering 62.82 km. It is estimated that the archaeological survey sampled approximately 5 km^2 or approximately 12% of the study area. Survey transects are shown on Figure 16-1.

Ground surface visibility was generally high across the study area owing to the high levels of pastoral land use and grazing.

Aboriginal cultural heritage sites identified during the survey were documented, photographed and locations recorded using a handheld GPS unit.

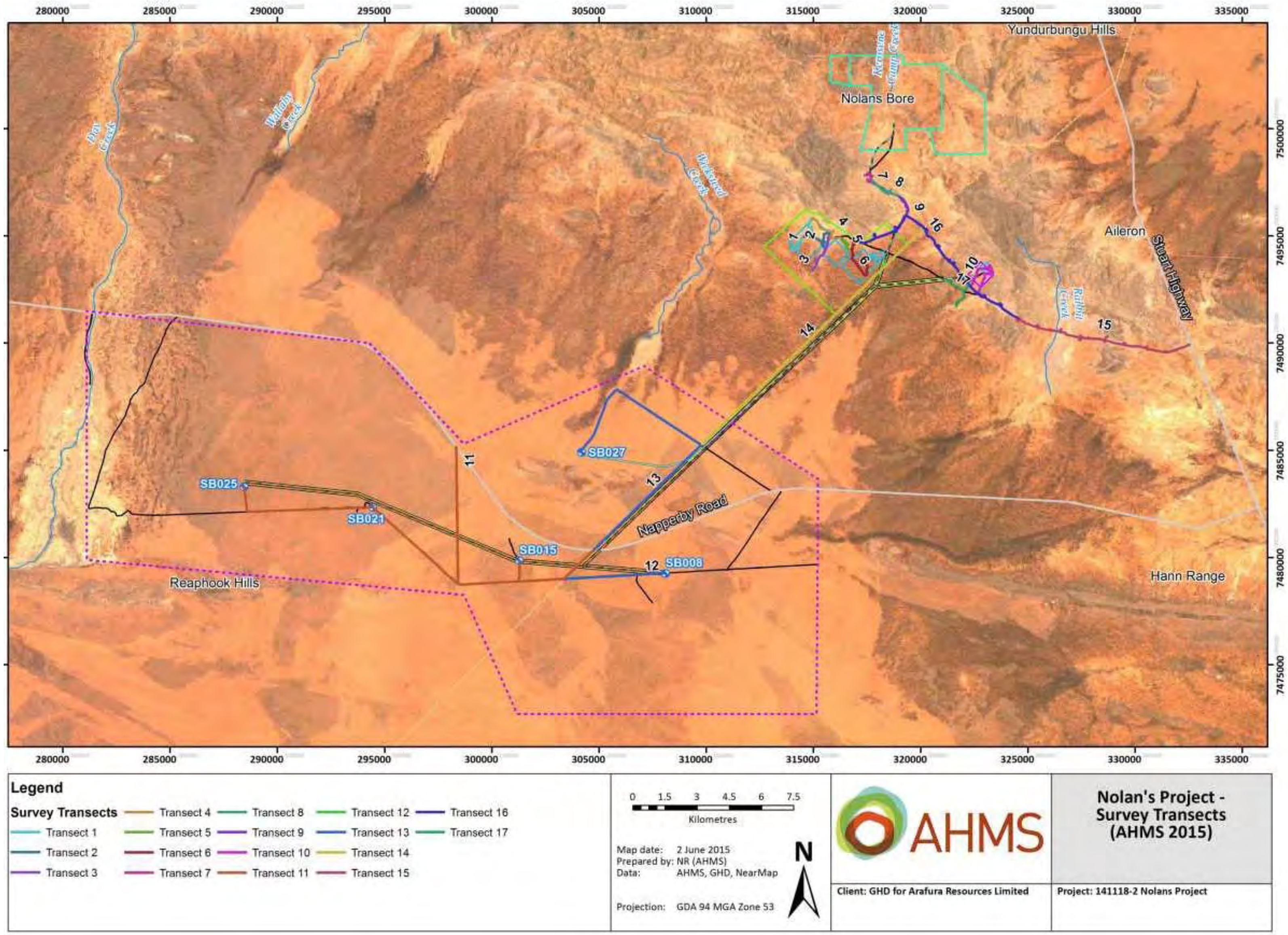


Figure 16-1 Survey transects

16.2.4 Aboriginal consultation

Traditional owners were unable to participate in the heritage survey. Efforts were made to arrange an on-site meeting however it was not possible to discuss the survey with the Anmatyerr traditional owners during the field investigation. Thus, it is possible that the heritage assessment provides an under-representation of cultural sites and/or values associated with the study area.

The heritage assessment (Appendix U), and the findings of previous archaeological reports for the Nolans Project, were provided to the Central Land Council prior to submission of the EIS, and will inform the negotiations between Arafura and the traditional owners.

16.3 The environmental, ethnographic and archaeological context

16.3.1 Environmental context

The study area is geologically part of the complex Aileron Province of the Arunta Region, with a high diversity of metamorphosed and igneous rock types. The major geological formation within the study area is the Napperby Gneiss, consisting of medium even-layered granitic gneiss, and minor porphyritic granite.

The study area is located to the north of the area known as the Ngalia Basin. Dolerite and basalt dykes occur within the basin. Chert concretions and nodules of grey, black and white chert also occur in areas of claystone.

The types of materials that occur within the Aileron Province and Ngalia Basin with properties suitable for the production of knapped tools include quartz, orthoquartzite, quartzite, siltstone, cherts (re-crystallised in calcretes), greywacke, and hornfels. Quartz was an important raw material used for stone tool production by Aboriginal people.

Gneiss is a foliated metamorphic rock, generally not suitable for the production of knapped stone tools owing to its structurally inherent fracture planes. In historic contexts, gneiss is known to have been used as a building material and is commonly referred to as granite.

Permanent soaks are known to occur in shallow alluvium along some major watercourses, including Napperby Creek to the west of the study area, and the Lander River to the north-west. These areas were important camping places for Aboriginal people in times of drought, and meeting places for large ceremonial gatherings. Surface drainage closer to the mine site is dominated by small ephemeral streams, with Kerosene Camp Creek in the north of the study area, w; and Rabbit Creek in the east, crossing the site access road from the Stuart Highway. There is no surface drainage on the sand plain within the borefield area.

16.3.2 Ethnographic and historical context

The study area is within the administrative boundary of the Central Land Council and is the traditional country of the Anmatyerr people.

Anmatyerr country is located several hundred kilometres north of Alice Springs and generally extends from Mt Allan in the west, to the Sandover outstation in the east, and from Stirling Range in the north to Native Gap in the south.

The Anmatyerr perceive the land as comprising more or less discrete countries. Each country is associated with one or more of the *Altyerrenge* beings (Dreaming) and contains sites marking the scenes of their travels and activities.

In the early twentieth century, the Anmatyerr were nearly wiped out as a result of drought and conflicts over land use in the 1870s, following construction of the Overland Telegraph Line, gold mining in the Tanami, and the establishment of pastoral interests. The Anmatyerr survived, but in depleted numbers.

A range of plant species and their traditional uses has been recorded by Anmatyerr women including fruit and vegetables, edible seeds, sweets, medicine, edible grubs, toys, tobacco, ashes and other plant uses. There is a high diversity of resources available in the arid zone and a depth of traditional ecological knowledge associated with complex plant use by Indigenous central Australians.

The early European settlement of the central Northern Territory was largely characterised by gold mining in the Tanami region (north-west of the study area); and the development of the pastoral industry between Alice Springs and Tennant Creek. These historical developments not only defined the European experience of central Australia but also had significant impacts on traditional Aboriginal life and occupation within the region.

The first Europeans to traverse the region were John McDouall Stuart in 1862, in an attempt to cross the Australian continent from south to north; and William Christie Gosse in 1873, on an expedition to find a route from central Australia to Perth.

The Australian Overland Telegraph Line, built between 1870 and 1872, opened up central Australia to European settlement. Overland Telegraph Line repeater stations offered safe havens to travellers, and its chain of wells formed a corridor for the movement of pastoral interests into the region. After gold was discovered at the start of the 20th century, miners on their way to the Tanami and Granites goldfields also passed through the area.

In 1876, the South Australian government began to issue pastoral leases in central Australia. The Barrow Creek Pastoral Company established a homestead in 1884 at Annas Reservoir, a waterhole to the north west of the study area described and named by Stuart and stocked cattle and breeding stock. This is also a sacred site locality known to the Anmatyerr as *Angkwerl* (McCarthy 2008b; Gunn 2004). The homestead was abandoned shortly after 1884 owing to escalating conflict with Aboriginal people arising from establishing the homestead at this location (*South Australian Register* 1891).

Wells were established further away from existing waterholes and rockholes, with Ryan Well built in 1889 to the east of the study area. The Glen Maggie Homestead was established in 1914 as a sheep and cattle station, as well as local area post office, which was later upgraded to the telegraph office in 1923. The station was eventually sold and renamed Aileron and continues to operate as a working pastoral station.

Glen Maggie Homestead also has significant cultural heritage values for the Anmatyerr, as Senior Anmatyerr traditional owner, Eric Penangk (or Panangke) was born at the station in 1927. Mr Penangk's father and mother worked at the station, and his father's job involved drawing water from Ryan Well (known in Anmatyerr as *Atnyem Kwaty*). The family would travel to the various wells and stay at each for a number of weeks (McCarthy 2008a). Indigenous workers lived in camps in the vicinity of the homestead and would receive rations and the occasional bullock from the station owners.

The Stuart Highway was established during World War II, with a hotel and service station later constructed at Aileron Station adjacent to the road. Following the Ti-Tree Land Claim in the 1980s, the local Aboriginal outstation settlement developed into the small community at Alyuen.

World War II saw developments concentrated along the Stuart Highway to the east of the study area. In central Australia, most military infrastructure related to the movement of materiel and troops to and from Darwin which was one of the central operating bases for the South West Pacific Area.

The study area is located on Aileron Station, which was established in 1929. Pastoral interests have been the major land use in the region, building infrastructure such as access roads and tracks, fences, water bores, and holding yards. Fibre optic cable is located along the Stuart Highway and the Alice Springs to Darwin Railway line.

Early Indigenous-settler conflicts

Several of the Northern Territory's most infamous Indigenous-settler conflicts occurred on Anmatyerr country. Conflict began at the beginning of pastoral settlement with Indigenous attacks occurring at Anna's Reservoir, where the homestead was established at a permanent waterhole. The conflict resulted in loss of cattle and damage to property, and the subsequent killings of the two principle leaders of the Indigenous resistance to the occupation of *Angkwerl*.

Aboriginal labour was also starting to be essential to the success of the growing pastoral industry, and the brand of violent frontier conflict that dominated the 1880s of central Australia started to change from one dominated by firearms to other coercive means.

Another infamous conflict arising between Europeans and Indigenous groups in central Australia was at a place called *Yurrkuru* or *Arrwek* (Brooks Soak), located to the west of Anmatyerr country (Olney 1992). It is the location where Fred Brooks, a dingo trapper, was killed by Aboriginal people in 1928, leading to reprisals culminating in the incident later known as the 'Conniston Massacre'. During the Conniston Massacre, local pastoralists under the leadership of Mounted Constable George Murray from Alice Springs were alleged to have shot in excess of 32 Aboriginal men, women and children.

The introduction of cattle to Aboriginal lands, coupled with competition for water resources due to drought conditions, has been given as reasons for the conflict.

A memorial was erected in 2003 by central Australian traditional owners, followed by an 80 year memorial built at Athimpelengkwe (Baxter’s Well) to commemorate those killed during the Conniston raids (McCarthy 2008b).

Regional archaeological context

Archaeological research in central Australia came to critical attention in the late 1960s and early 1970s following Richard Gould's ethno-archaeological work at Puntutjarpa rockshelter in the central arid zone of Western Australia.

An important part of Gould’s research alerted archaeological researchers to the diet of arid zone Indigenous groups with a low population density and high mobility in response to unpredictable and minimal rainfall; including a reliance on staple plant foods that varied with fluctuating environmental conditions, the use of grinders to process seeds, the gathering of small game, reptiles and other supplemental foods mostly by women, and frequent game hunting by men with minimal portable toolkits (Gould 1977).

Chronology of the population of the arid zone has been documented by the excavation of numerous rockshelter sites.

Pleistocene dates of 36,500 to 42,500 BP have been found from Puritjarra (Hiscock 2008). It is generally accepted that the current arid zones of Australia were significantly different during the Pleistocene, and Indigenous people occupied these areas early on after colonisation of the Australian continent.

Climate change occurred with worldwide interstadial glacial influences that had significant impacts on central Australian arid and semi-arid zones.

Three themes of particular relevance for interpreting the archaeological record within the study area are:

- Pleistocene and Holocene climate change
- The distribution, abundance and permanency of water sources and climate seasonality
- The species composition, distribution and abundance of economic plant species.

Owing to the close interdependency between desert ecology, climatic variation, and topography, these conditions would significantly influence the economic and social systems of the people that inhabited the arid zone.

Local archaeological context

Previous archaeological investigations for the Nolans Project include surveys of the proposed mine site by Gunn (2006), a proposed haul road corridor and parts of mineral lease EL 28473 by Earthsea Pty Ltd (2010), and additional parts of the mineral lease and proposed village site by Earthsea Pty Ltd (2012). There have also been several cultural heritage impact studies in the greater region of Anmatyerr country, mostly associated with the major transport and communications corridor of the Stuart Highway, Darwin to Alice Springs railway, and optic fibre cable assessments.

Anmatyerr country contains a number of sacred sites and places of past occupation. One place that has sacred, ceremonial, and archaeological significance is *Angkwerle* ('Angerle' in Gunn 2004) which is an important *Angkwerle* (Crow) dreaming site and rock art site located to the west of the study area. The site consists of a main waterhole, archaeological features and materials and a series of petroglyphs. Anmatyerr Custodians attributed the rock art formation to Crow and Porcupine dreaming. Gunn also suggests the site was used for general occupation and ceremonial purposes (Gunn 2004).

Gunn 2006

The Gunn 2006 archaeological survey of the Nolans Bore Prospect recorded a number of stone artefact scatters, several scarred trees and rock art sites, including two minor concentrations of stone artefacts (NB-1 & 2), six stone working areas associated with small quartz outcrops (NB-4 to 9), and a scarred tree (NB-3). According to Gunn (2006), a chalcedony quarry is located 10km to the north of the study area, explaining the presence of chalcedony artefacts in the area. A low granite/gneiss platform (AP-1) containing 29 grinding surfaces, petroglyphs (engravings) and a small amount of worked stone was also recorded.

An artefact scatter located along Kerosene Camp Creek reflects the importance of the watercourse for Aboriginal occupation in the area.

Earthsea Pty Ltd (2010)

Earthsea (2010) identified 12 archaeological sites in a survey to assess a proposed haul road corridor from Nolans Bore to the Alice Springs to Darwin Railway. These sites consist of three scarred trees, seven stone artefact scatters and quarry sites, one artefact scatter, and one engraving site. The report details eight isolated artefacts recorded during the study. It was concluded that the archaeology of the Nolans Bore area is highly localised and focussed on resource specific resource nodes which include raw material outcrop, localised areas of ecological resource abundance, and water supply.

Earthsea Pty Ltd (2012)

Further survey was conducted on areas within EL 28473 by Earthsea (2012) and eleven archaeological sites were recorded, in addition to a number of isolated artefacts. The sites consisted of stone artefact scatters and quartz quarry sites, where quartz was being sourced as a raw material. Lesser quantities of chalcedony, quartzite, chert and silcrete artefacts were also recorded within these sites. Earthsea predicted that mulga woodland was unlikely to contain archaeological materials, and that the majority of archaeological features would be confined to areas of quartz outcrop on the lower gravel slopes and rises, and around outcrops of granite/gneiss.

16.3.3 Previously recorded Aboriginal sites

Thirty-four Aboriginal sites and/or objects have been recorded during previous archaeological surveys undertaken for the Nolans Project at the proposed mine site. The most common site features are quarries (exclusively in the vicinity of quartz outcrops) and artefact scatters, which are frequently recorded in association with the quarries; followed by scarred trees. A smaller number of petroglyphs, reduction areas and a grinding surface have also been identified (Table 16-1 and Figure 16-2).

No Aboriginal sites or places within the study area are currently subject to a Declaration under the Aboriginal and Torres Strait Islander Heritage Protection Act 1984, or listed on the National Heritage List or Commonwealth Heritage List.

Table 16-1 Types of previously recorded Aboriginal sites in the vicinity of the study area

Site feature	Site name	Site count	% of total
Quarry	NB-4, NB-5, NB-6, NB-7, NB-8, NB-9, Site 12, Site 13	8	23.53
Artefact scatter	NB-1, NB-2, Site 2, Site 10, Site 11, Site 15, Site 18, Site 19	8	23.53
Quarry; artefact scatter	Site 3, Site 4, Site, 5, Site 6, Site 7, Site 8, Site 14	7	20.59
Scarred tree	NB-3, SP-1, SP-2, Scar 1, Scar 2, Scar 3	6	17.65
Quarry; reduction area	Site 16, Site 16, Site 17	2	5.88
Petroglyph	AP-1, Site 9	2	5.88
Quarry; artefact scatter; grinding surface	Site 1	1	2.94
Total		**34**	**100**

This figure has been removed to respect and protect the cultural sensitivities of the area following consultation with the Central Land Council and Traditional Owners.

16.3.4 Sacred sites

Arafura has undertaken sacred site clearance in the study area, and Authority Certificates were issued by AAPA in 2008 (C2008/205) and 2013 (C2013/205). Copies of the AAPA Certificates are attached to the Indigenous and Historic Cultural Heritage Assessment (Appendix U).

There are a number of sacred sites in the study area. Sacred sites are usually associated with creeks, waterholes, and/or geological outcrops; which archaeological survey has also found to contain archaeological materials and features.

One Restricted Works Area 8 (RWA8), associated with sacred site 5552-30, has been recorded within the project footprint. The features of sacred site 5552-30 described in the Authority Certificate issued by the AAPA include stone arrangements, soakages and rockholes.

16.3.5 Native title

There is one native title determination covering part of the study area, and two registered claimant applications.

- National Native Title Register: DCD2013/001 – Napperby Perpetual Pastoral Lease and
- Register of Native Title Claims: DC2014/002 – Aileron Pastoral Lease and DC2007/002 – Aileron.

16.3.6 Historic sites

There have been a number of investigations of historic (non-Aboriginal) cultural heritage places in the surrounding region which have resulted in the declaration of several nearby properties on the Northern Territory Heritage Register (Table 16-2). These places are representative of the type of historic features that may survive within the study area.

Three places in the vicinity of the study area are declared heritage places (Table 16-2). Of these, Aileron Homestead and Ryan Well Historical Reserve are the closest, being located within 10 kilometres of the study area.

Table 16-2 Declared heritage places in the vicinity of the study area

Name	Type	Gazetted	Status	Location	Relationship to subject area
Aileron Homestead No 1	Place	16 November 2005	Declared	NT Portion 6057(A) Stuart Highway	5.5 km north of the proposed access road
Ryan Well Historical Reserve	Place	8 February 1995	Declared	NT Portion 1282 Stuart Highway	3.5 km south of the proposed access road
Annas Reservoir Conservation Reserve	Place	8 February 1995	Declared	NT Portion 1281 Aileron Station	10 km to the north-east of mine area

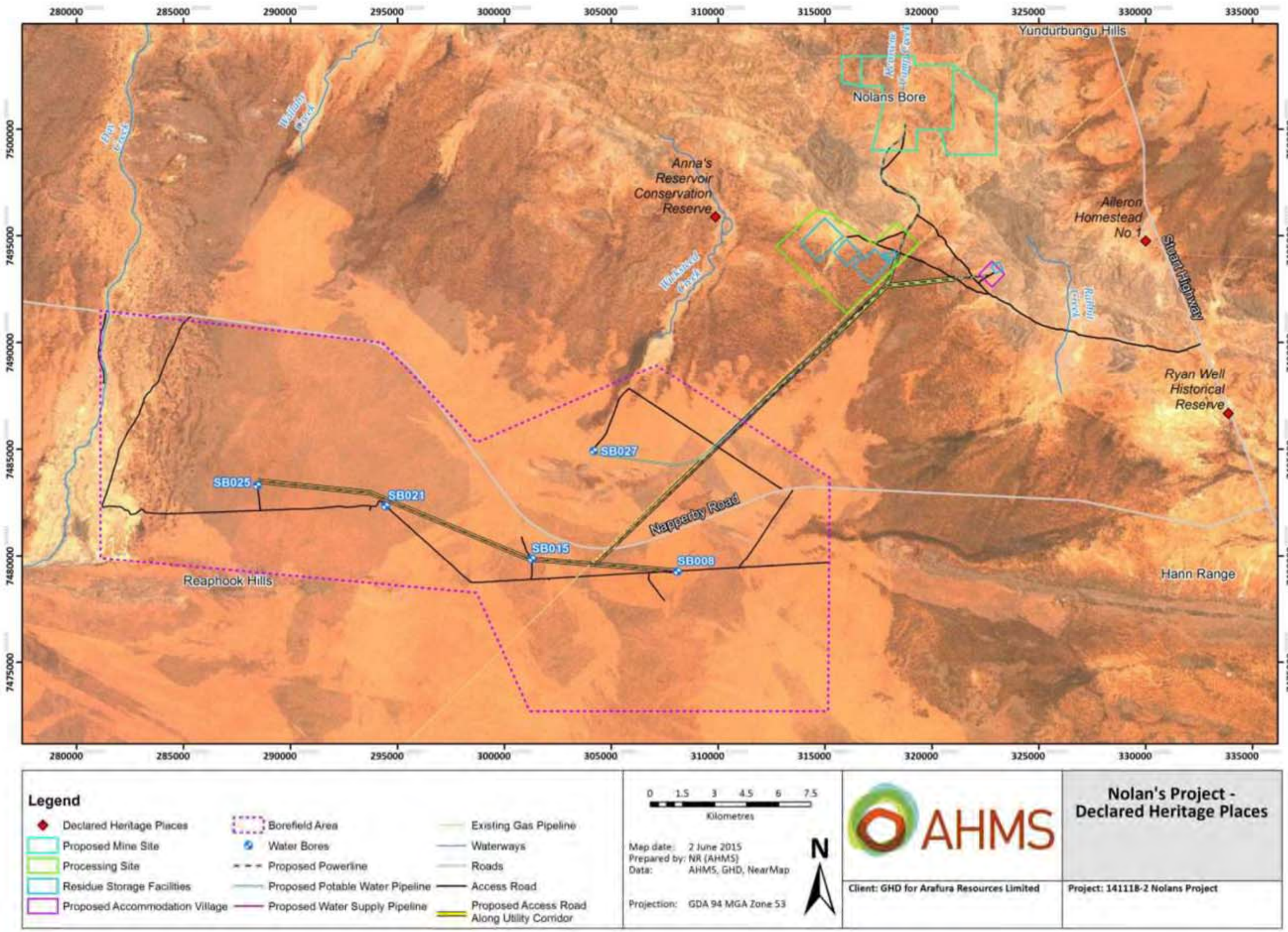


Figure 16-3 Declared heritage places in the vicinity of the study area

16.3.7 Results of field investigation

During field investigation 32 Aboriginal sites (Table 16-3) and 46 isolated artefacts (Table 16-4) were recorded. In addition, one potential historic site was identified (Table 16-5). Three of the Aboriginal sites are located within Restricted Works Area (RWA8), associated with sacred site 5552-30.

Archaeological sites were particularly dense near the Yalyirimbi Range in the vicinity of the proposed accommodation village, and the narrow valley between the processing site and the mine site where the access road and service corridor are proposed to be located. Archaeological sites and isolated artefacts were less frequent on the Quaternary deep red earths within the borefield area to the south. The study found the Yalyirimbi Range to be a particularly archaeologically sensitive zone, as many of the largest archaeological sites were identified in the vicinity of strike ridges and rock outcrops. The location of each archaeological site in relation to the proposed infrastructure is described in Table 16-6 and shown in Figure 16-4 to Figure 16-7.

Quartz was the main type of raw material found in the study area, owing to its association with the gneiss outcrops as a raw material source. A diversity of stone artefacts and raw materials were recorded in this study. This included utilised, retouched, pounding, and ground stone artefacts made of raw materials such as chalcedony, chert, silcrete, gneiss, quartzite, ortho-quartzite, basalt, and dolerite.

The archaeological site and artefact assemblage distribution documented here emphasises the importance of the Yalyirimbi Range to Aboriginal people in the past, based on the number of sites, and abundance and diversity of artefacts identified, compared to those recorded during previous archaeological surveys at Nolans Bore. However, a high proportion of the archaeological sites have been impacted by pastoral land use and erosion.

The 110 years of pastoral land use in the study area has significantly affected the structural integrity of the Quaternary alluvial and deep red earth soils. It is estimated that over 80% of the archaeological sites have had some form of significant erosion or disturbance from pastoral and other land uses. Several sites located on the lower slopes of the steep gneiss ridge generally had lower levels of impact as these areas are not heavily trafficked by cattle.

Sites located nearby existing tracks and on sloping alluvial plains were the most severely impacted from erosion and pastoral land use. Stone artefacts at many of the sites located on the alluvial plains had clearly been washed and eroded into their current locations.

Site NP-19 had 20% of the site area disrupted by a water bore drilling program.

The heritage significance of Aboriginal archaeological sites has been assessed using the four criteria outlined in the *Australia ICOMOS Burra Charter, 2013* (the Burra Charter); aesthetic, historic, scientific, and social or spiritual significance (Australia ICOMOS 2013). Aboriginal sites recorded during the field survey were ranked from low to high archaeological significance. The ranking of significance is as follows:

- **Low archaeological significance:** The site or object is common in the local area and/or the Northern Territory. The site has low excavation/research potential.
- **Moderate archaeological significance:** The site or object is rare in the local area, and/or has a high artefact density. The site has the potential to answer research questions that can add to our understanding of pre- or post-contact Aboriginal land use and occupation of the local area.

- **High archaeological significance:** The site or object is rare in the Northern Territory, or the site is a representative (and intact) example of a type of site that may be common elsewhere. The site has the potential to answer research questions that can add to our understanding of pre- or post-contact Aboriginal land use and occupation of central Australia or the Northern Territory.

Isolated artefacts recorded in this archaeological survey have low archaeological significance.

The location of each archaeological site in relation to the proposed infrastructure is described in Table 16-6. All archaeological sites identified during the field investigation are mapped in Figure 16-4 to Figure 16-7.

Table 16-3 Aboriginal sites identified during the survey

Site features	Site name	Archaeological significance
Artefact scatter	NP-3, NP-15	High
	NP-12, NP-13, NP-14, NP-19, NP-28,	Moderate
	NP-4, NP-5, NP-7, NP-8, NP-16, NP-17, NP-18, NP-20, NP-22, NP-24, NP-25, NP-30	Low
Artefact scatter; quarry	NP-6, NP-11, NP-26, NP-27, NP-31	High
	NP-21	Moderate
Artefact scatter; quarry; reduction area	NP-9, NP-10	High
Artefact scatter; engraving	NP-1	High
Artefact scatter; habitation structure; grinding surface	NP-2	High (within RWA 8)
Artefact scatter; quarry; grinding surface	NP-23	High
Rockshelter; artefact scatter	NP-29	High
Site complex; artefact scatter; quarry	NP-32	High

Table 16-4 Isolated artefacts recorded during the survey

Artefact type	Site name
Flake	NP-ISO-1-1, NP-ISO-7-2, NP-ISO-8, NP-ISO-10, NP-ISO-11-1, NP-ISO-18-1, NP-ISO-18-2, NP-ISO-19, NP-ISO-20, NP-ISO-22-2, NP-ISO-22-3
Grindstone	NP-ISO-1-2, NP-ISO-13-1, NP-ISO-25
Bifacial flaked artefact	NP-ISO-1-3, NP-ISO-23, NP-ISO-24
Retouched flake	NP-ISO-2, NP-ISO-3, NP-ISO-5-1, NP-ISO-29-1
Distal flake	NP-ISO-4

Artefact type	Site name
Distal retouched flake	NP-ISO-5-2
Core	NP-ISO-5-3, NP-ISO-6, NP-ISO-7-1, NP-ISO-9, NP-ISO-12-1, NP-ISO-12-2, NP-ISO-13-2, NP-ISO-14, NP-ISO-15, NP-ISO-16-1, NP-ISO-16-2, NP-ISO-17, NP-ISO-21-1, NP-ISO-22-1, NP-ISO-26, NP-ISO-28-1, NP-ISO-28-2, NP-ISO-29-1, NP-ISO-30-1, NP-ISO-30-2
Transverse broken flake	NP-ISO-11-2
Pounder	NP-ISO-21-2
Muller	NP-ISO-27

Table 16-5 Potential historic site identified during the survey

Site name	Site features
Old Albs Bore and Yard	Water tank, stock yards, Southern Cross windmill

This figure has been removed to respect and protect the cultural sensitivities of the area following consultation with the Central Land Council and Traditional Owners.

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Table 16-6 Archaeological sites and isolated finds within the curtilage of proposed infrastructure

Proposed infrastructure	Archaeological sites
Confidential	NP-4; NP-5; NP-6; NP-7; NP-8; NP-9
	NP, NP-16, NP-17, NP-18
	NP-21; NP-22; NP-23; NP-24; NP-25; NP-26; NP-27; NP-28; NP-29;
	NP-1, NP-2, NP-3 NP-10; NP-11 NP-30, NP-32
	NP-19; NP-20
	NP-12, NP-13, NP-14, NP-15, NP-31

16.4 Potential impacts

The level of risk posed to cultural heritage values by each source of impact was assessed using standard qualitative risk assessment procedures, which have been described in Chapter 5 (Risk assessment). The risk associated with each potential impact is detailed in the risk matrix, which is contained in Appendix F.

Without some form of mitigation, archaeological resources recorded in this survey will be unknowingly impacted by the proposed infrastructure. In addition, given that the field survey covered approximately 12% of the study area, it is also likely that additional archaeological material is present. There is also potential for additional sub-surface archaeological materials, most notably in the creek banks of the Quaternary alluvial plains at NP-14.

A high proportion of the archaeological sites were located in association with specific features such as outcrops of gneiss domes and platforms, basalt outcrops, at the base of the steep ridges and over the lower gneiss foothills. Avoiding these types of landscape features, where possible, would reduce the risk of impacting unknown archaeological resources.

Whilst all Aboriginal archaeological places and objects are protected under NT legislation, destruction of sites may be necessary to allow other activities or development to proceed.

Consideration of the level of significance of cultural heritage places and objects (as shown in Table 16-3) is important for determining appropriate impact management measures for sites.

Table 16-7 lists the archaeological management measures for each site based on their level of significance.

A Cultural Heritage Management Plan (Appendix X) will be implemented during project construction and operation and includes:

- procedures to avoid significant sites and areas
- procedures to enable protection of key sites during construction, operation and decommissioning work
- measures to enable the Proponent to meet its duty of care to protect the cultural and heritage values of any places or items of significance

- procedures for the discovery of surface or sub-surface items during the course of the Project.

16.4.1 Risk assessment

- During site establishment (including excavation, earthworks, vegetation clearing and establishment of project infrastructure) there is a medium risk of physical disturbance to sites and/or objects of heritage significance that may result in damage or destruction. This level of risk is based on an understanding that some sites will be subject to direct impact a result of the project. Overall, 67 Aboriginal archaeological sites (including 34 isolated artefacts) would be subject to direct impact. Of note are artefact scatters and a quarry with potential subsurface archaeological deposit, which have research potential (NB-2, Site 19, NB-4); intact examples of artefact scatters and quarries; and scarred trees (Scar 3, SP-1, and SP-2) which are regionally rare. Permits will be sought from the regulatory authorities prior to site disturbance and in conjunction with communication with Anmatyerr traditional owners and their representatives.
- During site establishment there is a low level of risk, notwithstanding the implementation of the Cultural Heritage Management Plan, that inadvertent damage, destruction or removal of heritage items or sites will occur through discovery of, as yet unidentified sites. Site requirements will include pre-clearing survey and visual inspections to mitigate this risk.
- There is also a low level risk that during construction or operations, identified sites are inadvertently damaged by site personnel (i.e. non-compliance).
- There is an additional low level risk that construction or operational activities could also result in indirect impacts (e.g. vibration or dust related impacts, minor construction and vehicle impacts) that may alter the character of scared sites or heritage places. Overall, 62 Aboriginal archaeological sites (including 35 isolated artefacts) and one potential historical site would be subject to indirect impact. Of note are a rockshelter with potential subsurface archaeological deposit and an associated low density artefact scatter (NP-29) which is locally rare, and scarred trees (Scar 1, Scar 2) which are regionally rare.

The most significant area of potential heritage impact is the geographic bottleneck created by a saddle in the Yalyirimbi Range, through which the access road and proposed service corridor are routed to the mine from the processing site. This has the potential to directly impact archaeological objects that have high archaeological and cultural significance.

A high density of archaeological material has been recorded at Sites NP-1, NP-2, NP-3, and NP-32. Sites NP-1, NP-2, NP-3 are located within the AAPA Certificate Restricted Works Area RWA8. It is estimated that there is likely to be in excess of 25,000 stone artefacts located within this area.

The archaeological survey identified a more or less continuous scatter of archaeological materials along the proposed service corridor between the mine site and processing site, owing to a combination of factors significant to Aboriginal occupation of the area; including raw material resources, ecologically rich grassland resources on the alluvial plain, the presence of an incised creek system, and a major access route through the range to Kerosene Camp Creek.

Two Restricted Works Areas, RWA9 and RWA10, associated with sacred sites 5552-41 and 5552-44 respectively, are adjacent to the Project area and would be subject to potential indirect impact. RWA9 is located on the southwest boundary of the processing site. The features of sacred site 5552-41 include a hill and swamp. RWA10 is located to the west of an access track between the Napperby Road and borefield Area. The features of sacred site 5552-44 include a rocky ridge and sand dune.

An Authority Certificate was issued by the APAA in 2013 (Appendix U) identifying conditions covering mineral exploration activities inclusive of water drilling, reconnaissance visits in 4WD vehicles, access with drilling rig and support vehicles and minor vegetation clearing at discrete locations (C2013/205). The conditions specify that no work shall take place or no damage shall occur within RWA8, RWA9, and RWA10.

A new Authority Certificate from the APAA will be required prior to commencement of the construction phase of the Project.

16.5 Mitigation measures

The management and mitigation measures identified for cultural heritage items within the Project area are based on:

- Anticipated impacts to heritage items;
- Assessed scientific (archaeological) significance, and (where known) overall heritage significance;
- Legislative requirements and the planning approval framework;
- Recommendations in previous archaeological survey reports; and Heritage best practice in accordance with the principles of the Burra Charter.

Where possible, options to avoid adversely impacting identified heritage items will be considered. However, the construction phase of the Project cannot completely avoid harm to heritage items. Where items cannot be avoided, further works are recommended in order to mitigate impacts. A summary of archaeological management recommendations is presented in Table 16-7.

The following additional mitigation measures will be implemented for the project as part of a Cultural Heritage Management Plan:

- Consideration will be given to realigning the proposed access road and service corridor in order to avoid or reduce impact to RWA8. Once the design has been finalised, an archaeological mitigation program would be put in place to sample, collect and document a representative sample of archaeological materials between 318843E-7496897N to 317744E-7498669N which covers the area of possible alternative routes.
- A 50 m buffer will be maintained around sites to be avoided, to protect against inadvertent damage.
- Where proposed infrastructure is within 50 m of an archaeological site, temporary fencing will be erected during construction and/or sites appropriately signposted. Anmatyerr traditional owners and custodians will be engaged in the process of developing and installing appropriate fencing and signage.
- Infrastructure will be set back from the base of steep ridges and lower gneiss foothills to avoid archaeological sites associated with geological features such as outcrops of gneiss and basalt. Where impacts are unavoidable, archaeological mitigation will be required.
- Where there is an unavoidable impact to archaeological sites where archaeological mitigation has been recommended, a research plan for an appropriate recording and salvage program will be required. The research plan will be submitted to the Chief Executive Officer of the Department of Lands, Planning and the Environment as supporting documentation for an Application to Carry out Work on Heritage Place or Object (work approval application).

- Consultation with Anmatyerr traditional owners will be undertaken to determine whether they wish to collect artefacts of low archaeological significance prior to sites being impacted.
- The Anmatyerr traditional owners and custodians will be consulted regarding the proposed management recommendations, and their approval sought prior to submitting a work approval application for archaeological mitigation or permission to disturb Aboriginal archaeological places and objects within the study area.
- Anmatyerr traditional owners and custodians will be engaged in future archaeological work undertaken for the Nolans Project, including participation in future archaeological mitigation works.
- A Cultural Heritage Management Plan will be maintained that addresses the potential impacts of the project to the local Aboriginal community.
- Cultural heritage management issues will be incorporated into the environmental management plan for the construction phase of the Nolans Project.
- A copy of the heritage assessment will be submitted to the CEO of the Heritage Council, to fulfil the requirements of notification of the location of Aboriginal archaeological places and objects in accordance with the Heritage Act.

Table 16-7 Summary of archaeological management recommendations

Management recommendation	Proposed infrastructure	Archaeological significance	Site name
Impact avoidance	Confidential	High	NP-1, NP-2, NP-3
		High	NP-6
		Low	NP-7
		NA	Old Albs Bore and Yard
		High	NP-9
		High	NP-10, NP-11
		High	NP-15
		Moderate	NP-12, NP-13, NP-14
		Moderate	NP-19
		Low	NP-20
		High	NP-23, NP-27, NP-29, NP-31
		Moderate	NP-21, NP-28
		Low	NP-22, NP-24
		Low	NP-4, NP-5, NP-8

Management recommendation	Proposed infrastructure	Archaeological significance	Site name
Work approval application and archaeological mitigation		Low	NP-16, NP-17, NP-18
		High	NP-26
		Low	NP-25, NP-30
		High	NP-32
Work approval application		Low	NP-ISO-1-1, NP-ISO-1-2, NP-ISO-1-3, NP-ISO-2, NP-ISO-3, NP-ISO-4, NP-ISO-5-1, NP-ISO-5-2, NP-ISO-5-3, NP-ISO-6, NP-ISO-7-1, NP-ISO-7-2, NP-ISO-8, NP-ISO-9
		Low	NP-ISO-10, NP-ISO-11-1, NP-ISO-11-2, NP-ISO-12-1, NP-ISO-12-2, NP-ISO-13-1, NP-ISO-13-2, NP-ISO-14, NP-ISO-15, NP-ISO-16-1, NP-ISO-16-2
		Low	NP-ISO-17, NP-ISO-18-1, NP-ISO-18-2, NP-ISO-19, NP-ISO-20, NP-ISO-21-1, NP-ISO-21-2, NP-ISO-22-1, NP-ISO-22-2, NP-ISO-22-3, NP-ISO-23, NP-ISO-24, NP-ISO-25, NP-ISO-26, NP-ISO-27, NP-ISO-28-1, NP-ISO-28-2, NP-ISO-29-1, NP-ISO-29-1, NP-ISO-30-1, NP-ISO-30-2

17

Traffic and transport

17. Traffic and transport

17.1 Introduction

This chapter describes the existing transport infrastructure (road and rail) and traffic conditions in the study area, and describes the potential impact on the public road network and on rail freight services arising from the Nolans Project during operation. Mitigation measures that will be implemented to minimise the impact of the project on transport networks are also discussed.

The level of risk to transport networks posed by each source of impact was assessed using standard qualitative risk assessment procedures, which have been described in Chapter 5 (Risk assessment). The risk associated with each potential impact is detailed in the risk matrix, which is contained in Appendix F.

Section 5.9.1 of the Terms of Reference for the preparation of an environmental impact assessment issued by the NT EPA for the Project in particular provided the following environmental objective in relation to transport:

> *Potential transport impacts will be effectively identified and avoided/mitigated/minimised to the greatest practicable extent.*

A detailed transport study is provided in Appendix V.

17.2 Methodology

The following tasks were undertaken to complete the transport assessment:

- Review of existing transport conditions.
- Review of the proposed development in terms of location, access and the amount of material being imported and exported.
- Assessment of the impacts on the road network. This includes an analysis of the amount of traffic the project is expected to generate and how it will use the road network. Impacts are described in terms of reductions in spare capacity, based on published capacity guidelines.
- Assessment of impacts on the rail network. This includes an examination of current rail services and the ability of the rail network to handle additional freight, together with an assessment of how existing services will be affected.
- Selection of mitigation measures to offset or reduce the identified impacts. These are generally physical changes to the road network to enhance capacity and/or road safety.

17.3 Existing environment

17.3.1 Existing road network

The Nolans site is located approximately 135 kilometres north-northwest of Alice Springs and 10 kilometres to the west of the Stuart Highway at Aileron Station, in the Northern Territory.

The site access alignment, five kilometres south of the Aileron Roadhouse, currently exists as an unsealed station track which would be upgraded to a two lane, two way sealed road during the construction phase of the project. It is located at an intersection with the Stuart Highway, within a section of open speed limit.

Key roadways within the study area are the Stuart Highway, Whittaker Street and Smith Street and are shown in Figure 17-1.

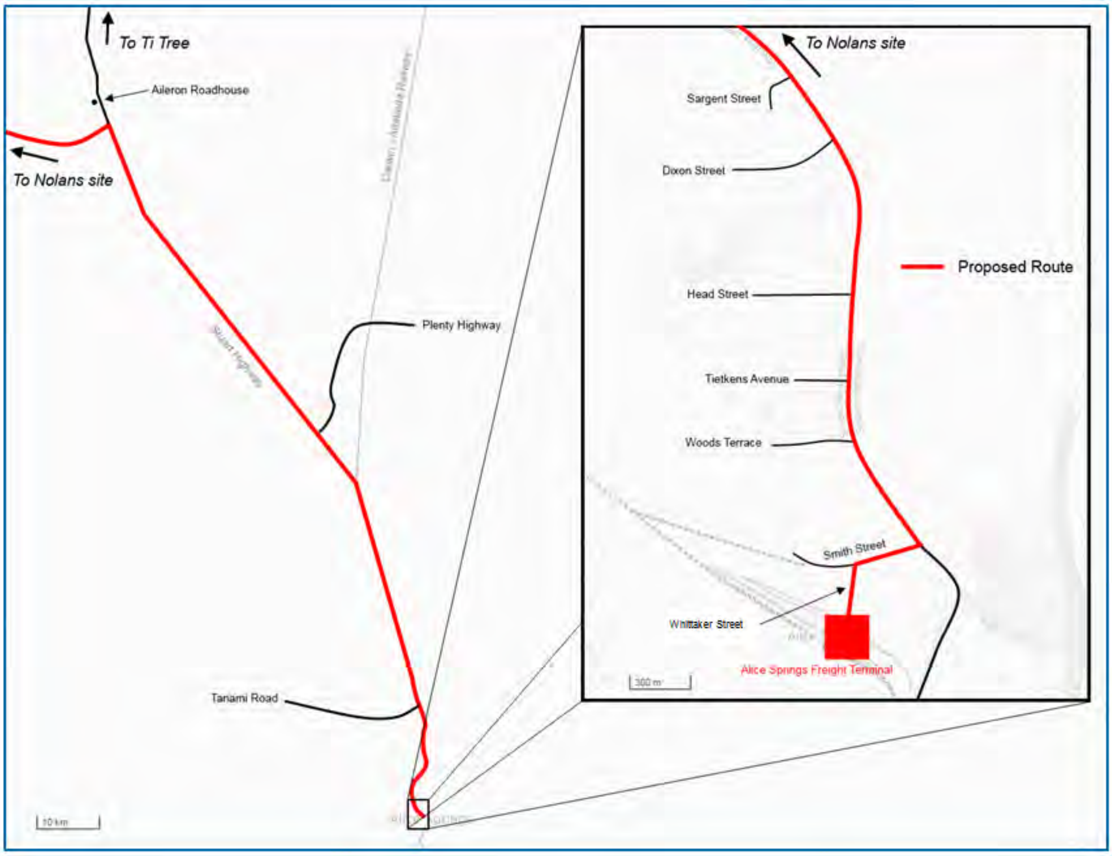

Figure 17-1 Study area and proposed access route from Alice Springs

Whittaker Street

Whittaker Street comprises of two sections – an east-west undivided road that provides access to local traffic, and a north-south divided road which is the primary access to the Alice Springs freight rail terminal. Both sections have one lane in each direction and the default speed limit (i.e. not signposted) of 60 km/h applies.

Smith Street

Smith Street is a generally light industrial, east-west single carriageway road with one lane in each direction. It is linked to the north-south section of Whittaker Street via a four-leg roundabout, which has a large overrun area for long vehicles in the central island. The east end of Smith Street connects with the Stuart Highway via an unsignalised T-junction, thereby forming the main route for vehicles accessing the Alice Springs freight terminal from the Stuart Highway. A default speed limit of 60 km/h applies to Smith Street.

Stuart Highway

Stuart Highway (National Route 1/National Route 87) is a national highway connecting Darwin, Katherine, Daly Waters, Tennant Creek, Alice Springs and Port Augusta in South Australia. Throughout the study area it is a sealed, approximately 7 m wide, generally two lane, single carriageway road with one lane in each direction. The maximum posted speed limit is 130 km/h, except for a 204 km section directly north of the Tanami Road intersection, where open speed limit trials commenced in 2014 and have since been made permanent. The intersection with the proposed site access will be located within this open speed limit section.

In Alice Springs, the Stuart Highway is a dual carriageway north of Smith Street through to Dixon Road. There are two lanes in the north bound direction until just north of Head Street, and two lanes in the south bound direction from Tietkens Avenue. At Dixon Road, the Stuart Highway reverts to a single carriageway, still with one lane in each direction, and remains in this configuration through to the site access near Aileron Roadhouse. From the city centre to Bitzer Road, the speed limit varies from 60 km/h to 70 km/h, gradually increasing to 110 km/h leaving Alice Springs. North of the Tanami Road, the open speed limit zone commences as described above.

Traffic volumes

Traffic volume information collected by the Department of Transport (DoT) has been provided for the study area for 2014. The records present annual average daily traffic (AADT) volumes at permanent counter locations.

The existing traffic volumes along each road section have been summarised in Table 17-1. These include both heavy vehicles and light vehicles.

Average daily traffic volumes vary significantly along the Stuart Highway, ranging from 13,522 vehicles per day (vpd) in Alice Springs to 381 vpd close to the project site access. No data was available for Whittaker and Smith streets.

Table 17-1 2014 AADT volumes within the study area

Survey location	AADT volumes (2014)
Whittaker Street	Unknown
Smith Street	Unknown
Stuart Highway, between Smith Street and Woods Terrace, Alice Springs	13,522
Stuart Highway, between Dixon Road and Sargent Street, Alice Springs	6,974
Stuart Highway, 3.0 kilometres north of Alice Springs	978
Stuart Highway, 1.5 kilometres north of Tanami Road	608
Stuart Highway, 8 kilometres north of Aileron	381

Road closures

According to DoT records, for the years 2003 through 2014, the Stuart Highway between Tanami Road and Aileron Roadhouse was closed twice due to flooding. In both cases, the closure was in effect for less than 24 hours.

There is no practical alternative route between the Alice Springs and the Nolans site.

17.3.2 Rail

Genesee Wyoming Australia (GWA) operates the rail corridor from Tarcoola (in South Australia) to Berrimah (in Darwin) under long-term lease agreement with the AustralAsia Railway Corporation who are the government owners of the infrastructure. GWA maintain and operate the track and provide rail access to other rail companies, including the Great Southern Railway. GWA also operate regular freight trains on the network.

The Tarcoola to Alice Springs railway is approximately 65 kilometres to the east of the Nolans site with limited direct roadway access and services. Access to rail services is more appropriate at Alice Springs with highway connections for linking road services.

Regular rail traffic from Adelaide to Darwin and return includes the intermodal containerised freight service operated by GWA six days a week and the Ghan tourist train one or two times weekly (seasonal). Other trains carrying bulk mining outputs from the Northern Territory operate to ports in South Australia or Darwin depending on transport costs and requirements. Recent changes in commodity prices have resulted in a reduction of services on the rail freight network. There is currently significant capacity available on the corridor as a result.

The rail corridor is a single line with passing loops at various intervals relative to the demand requirements on the corridor.

GWA access information indicates freight train access is available with axle weight capacities as follows:

- Northgate (South Australia) to Alice Springs: 21 tonne axle load up to 110 km/h
- Alice Springs to Darwin: 23 tonne axle load up to 115 km/h.

The rail line provides access to the intermodal facilities at the Alice Springs Freight Terminal (see Figure 17-2).

Figure 17-2 Alice Springs Freight Terminal

The rail corridor connects to the Port of Darwin at Berrimah with direct access onto port for unloading of containerised freight. Bulk unloading facilities are also available outside port environs although a further transport movement is required for loading to ship.

The northern end of the rail corridor at Berrimah (Darwin) is adjacent to the Port of Darwin East Arm Wharf facility which is the location of commercial port operations for containerised and bulk products. The rail corridor connects from the rail terminal to the port past a bulk fuel terminal operated by Vopak (also relevant to the supply chain) and directly onto the port berths.

17.3.3 Port facilities

The closest port facilities are located in Darwin (approximately 1,430 kilometres north of the Alice Springs Rail Terminal which would be used as a rail connection) and Adelaide (approximately 1,570 km to the south of this location).

Shipping options are available with rail connectivity at both Darwin (East Arm Wharf) and Port Adelaide. The East Arm Port at Darwin can provide access for the movement of containerised products, bulk materials and liquid bulk through the adjacent Vopak bulk liquids terminal and is the port favoured by the project.

17.3.4 Airport facilities

Alice Springs Airport is located approximately 145 kilometres south of the proposed site access road on Stuart Highway. A large number of domestic flights depart from and arrive at Alice Springs Airport each day from capital cities and smaller regional airports in the Northern Territory.

17.4 Potential impact on the transport network

The project is expected to generate operational traffic as a result of the following:

- Imports of consumables/reagents to the site
- Exports of RE products from the site
- Transportation of workers to/from the site.

Operation of the project will require the following resources to be transported to and from the Nolans site:

- Import of a range of products to the site such as fuel, bulk imported sulfur, sulfuric acid and reagents sourced internationally through the Port of Darwin. Other raw materials may be sourced locally if competitively priced. The majority of these products would be transported by rail to Alice Springs Freight Terminal and then by road to the Nolans site
- Other supplies such as diesel fuel would be brought to the Nolans site by rail and/or road, mostly via Alice Springs
- Rare earth intermediate products (outbound product) would be trucked by road from the Nolans site to Alice Springs Freight Terminal via the Stuart Highway, where they would be transported to Darwin Port via freight trains
- Transportation of workers between Alice Springs (or other nearby communities) and the Nolans site by road.

In addition, a number of vehicle movements would be required within the Nolans site. As these vehicles would not be on public roads, these have not been considered in the assessment.

17.4.1 Traffic generation

Imports of consumables

Demand for some minor consumables is expected to fluctuate over the life of the operation, however the majority of the consumables required are fixed quantities and do not vary. These are provided in Appendix V.

The summary results presented in Table 17-2 are based on the following assumptions:

- Each TEU (twenty-foot equivalent container unit) can carry 25 tonnes of solid consumables
- Each ISO (international standards organisation size tanks) can carry 20 tonnes of liquid consumables
- Quadruple road trains are to be used for each trip (i.e. four TEU/ISO per truck)
- The Nolans site is operational for 365 days per year.

Table 17-2 shows the number of TEU/ISO to be delivered to the site is forecast to remain relatively steady throughout the project's operational phase, fluctuating by less than one per cent to a maximum rate of 8,126 TEU/ISO per annum. Consequently, the number of return trips generated is also relatively constant from year to year at around 2,000 annual trips, or six return trips per day (or 12 one way trips on average per day).

Table 17-2 Trip generation from delivery of mine site consumables

	Yearly ISO/TEU demand	Yearly return trip generation	Average return trips per day
Lowest demand (year 1)	7,994	1,999	6
Highest demand (year 10 to 25)	8,126	2,032	6

Exports of products

Rare earth intermediate products would be exported by road to the Alice Springs Freight Terminal, where they would be transported to Darwin Port via freight trains. Incoming road trains delivering consumables to the Nolans site would return empty to Alice Springs, so it is likely that the available capacity on these returning road trains would be used to transport outbound product.

The volume of inbound consumables would far exceed the volume of outbound product. Therefore, the export of RE products from the site is not expected to generate any additional traffic.

Transportation of site workers

Operations workforce is expected to be in the range of 250-300.

Workers at the mine will be based on site in a 300-person accommodation village, and would rotate shifts according to a fly-in/fly-out (FIFO) or bus-in/bus-out (BIBO) roster. It is anticipated that FIFO workers will be flown into Alice Springs and taken by bus to the Nolans site via the Stuart Highway. Other local workers could come from a range of locations in the surrounding area, but generally no further away than Alice Springs and will likely also be bussed to the project site.

An indicative breakdown of the workforce is as follows:

- 70% FIFO (for the purposes of this assessment this means they originate at Alice Springs, as that is where their road journey starts);
- 10% relocated interstate workers (Alice Springs based);
- 10% local (effectively Alice Springs based); and
- 10% regional communities (based elsewhere in the NT).

Assuming that 10% of the 300 workers will be rotated each weekday (i.e. a full rotation occurs every fortnight), 30 workers will depart the site and 30 more will arrive at the accommodation village each day. This demand would likely require no more than two buses (one to service Alice Springs, one to regional areas north or west of Aileron), resulting in four trips per day for the purpose of transporting workers to and from the site (i.e. two daily departures and two daily arrivals).

To provide a robust analysis, it is assumed that bus movements occur during the peak hour; however, in reality at least half of these would likely be timed to coincide with aircraft arrivals and departures at Alice Springs Airport (which may or may not occur during peak hour).

In addition to rostered employees, external local contractors are expected to access the Nolans site in their own vehicles. These trips are expected to originate in or near Alice Springs and not exceed five arrivals and departures per day at the site. In instances when the accommodation village is fully occupied, staff may stay at the Aileron Roadhouse, near the access road intersection with Stuart Highway.

Summary of trip generation from project operations

Table 17-3 summarises the daily trip generation resulting from the project operations. Note that this includes only those trips made on the public road network. It does not include internal vehicle movements such as to and from the accommodation village or the Woodforde carbonate quarry.

Table 17-3 Daily trip generation from site

Trip purpose	No. of daily trips	Peak hour proportion	No. of peak hour trips
Imports of consumables (road train)	12	10%	2
Exports of products (road train)	0	10%	0
Transportation of site workers from Alice Springs (bus)	2	100%	2
Transportation of site workers from north of Aileron (bus)	2	100%	2
External contractors' vehicles (small vehicles/4WDs)	10	100%	10
Total	**26 (24)**	**-**	**16 (14)**

17.4.2 Contribution to the road network

Access to the site will be restricted to authorised commercial vehicles only, via the upgraded site access road connecting with the Stuart Highway approximately five kilometres south of Aileron Roadhouse.

Austroads publishes guidance on the capacity of roads and traffic lanes (Austroads 2009). Table 17-4 compares the estimated capacity remaining in the road network in year 1 both with and without the Nolans Project.

For the purposes of assessing traffic capacity, the highest traffic volume collected within each section has been considered in this report. An annual growth rate was applied to the 2014 background AADT volumes based on average historical increases between 2005 and 2014.

Table 17-4 Comparison of overall peak hour volumes

Road section		Capacity (vph)	Projected year 1 peak hour without Nolans Project		Projected year 1 peak hour with Nolans Project	
			Volume (vph)*	Remaining capacity	Volume (vph)	Remaining capacity
Stuart Highway, 2.2 km between Smith Street and Dixon Road**	North bound	900	667	26%	674	25%
	South bound	900	705	22%	712	21%
Stuart Highway, 400 m between Dixon Road and Sargent Street	North bound	900	472	48%	479	47%
	South bound	900	348	61%	352	61%
Stuart Highway, 16.5 km between Sargent Street and Tanami Rd	North bound	1,800	31	98%	38	98%
	South bound	1,800	36	98%	43	98%
Stuart Highway, 109 km between Tanami Rd and Aileron	North bound	1,800	18	99%	25	99%
	South bound	1,800	20	99%	27	99%

* Vehicles per hour

** Approximately 75% of this section has two lanes in one or both directions. To be conservative, the assessment has been made on the one-lane section.

Project traffic will not increase over time during operations, but background traffic volumes will; and therefore, as a proportion of total traffic, the Nolans contribution to traffic volumes will represent less and less each year. On this basis it is reasonable to consider the impact of the Nolans Project in its first year of operation (e.g. 2019).

Overall the project is unlikely to have a significant impact on the capacity of the key roads in the surrounding road network. It is anticipated that there would be only a very small increase in overall traffic volumes as a direct result of the Nolans Project (Table 17-4).

Intersections within Alice Springs

The intersections of Smith Street/Stuart Highway and Smith Street/Whittaker Street, as well as Smith and Whittaker streets themselves, are on an established truck access route into the Alice Springs Freight Terminal. Table 17-4 shows that the Stuart Highway in Alice Springs is expected to have at least 25 per cent spare capacity in 2019 with or without the Nolans Project.

Stuart Highway (rural)

Nolans Project traffic would form a larger proportion (approximately five per cent) of overall vehicles on the less trafficked sections of the Stuart Highway in close proximity to the Nolans site. However, this also demonstrates that the remaining capacity in these areas is abundant and the Nolans Project would have a negligible impact on the Stuart Highway.

17.4.3 Intersection assessment

At the location of the proposed Nolans site access road five kilometres south of Aileron Roadhouse, traffic associated with the project is forecast to comprise less than 4% of peak hour traffic along Stuart Highway in year 1.

Section 4.8 of the *Austroads Guide to Road Design – Part 4A: Unsignalised and Signalised Intersections* specifies for various left and right turn treatments leaving a major road, considering the number of vehicles making the turning movement, the volume of through traffic in one or both directions, and the design speed of the major road.

No more than 52 vehicles are expected to use the Stuart Highway during the year 1 peak hour, assuming that the peak hour traffic volume is equal to 10% of the daily volume (refer Appendix V).

For a design speed equal to or greater than 100 km/h, the Austroads specify that a basic auxiliary left/right treatment is suitable if there are less than 100 vehicles per hour travelling along the major road, or if there are less than five vehicles turning right or left onto the minor road. A basic auxiliary left/right treatment (“BAL” or “BAR”) is a localised road widening to allow a through vehicle to pass a turning vehicle, as shown in Figure 17-3.

However, the type of turning treatment provided should also consider other elements of the actual intersection location, such as steepness of grades, sight distances and speed limit. In particular, Austroads suggests that a BAL treatment would not be appropriate where numerous heavy vehicles travel quickly down a steep grade, and that a channelised left turn is a more suitable treatment in such instances. It is also considered that the open speed limit in this location potentially makes a BAL/BAR treatment unsafe.

Thus, although the BAR/BAL treatment is sufficient in terms of intersection capacity, it is considered that the open speed limit warrants the provision of a channelised treatment to improve road safety. An example of a channelised treatment is shown in Figure 17-4.

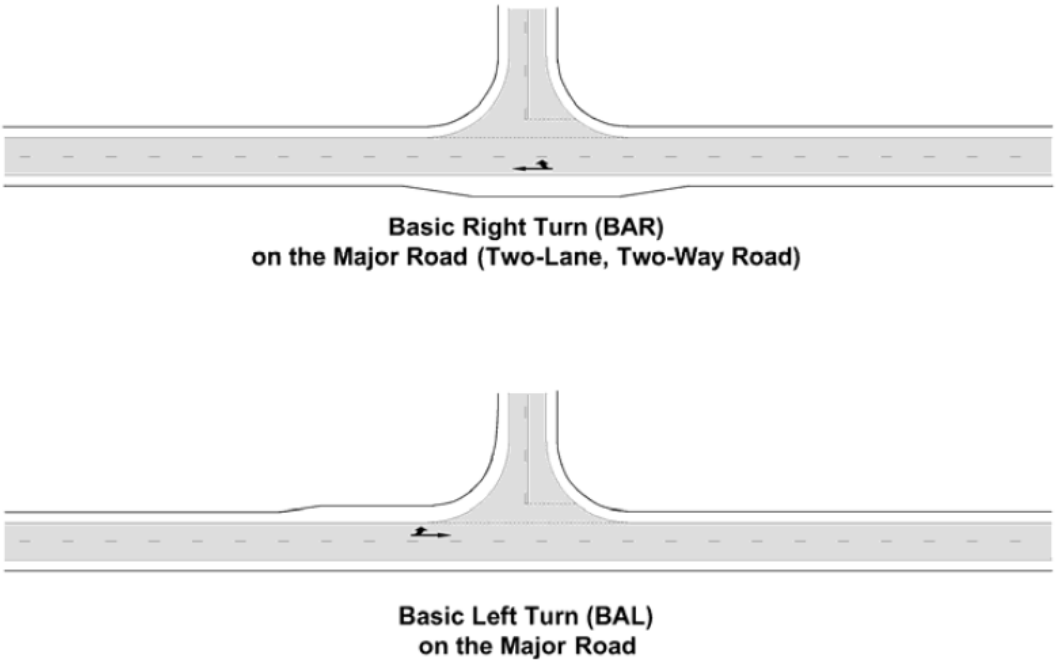

Figure 17-3 BAR and BAL treatments (reproduced from Austroads)

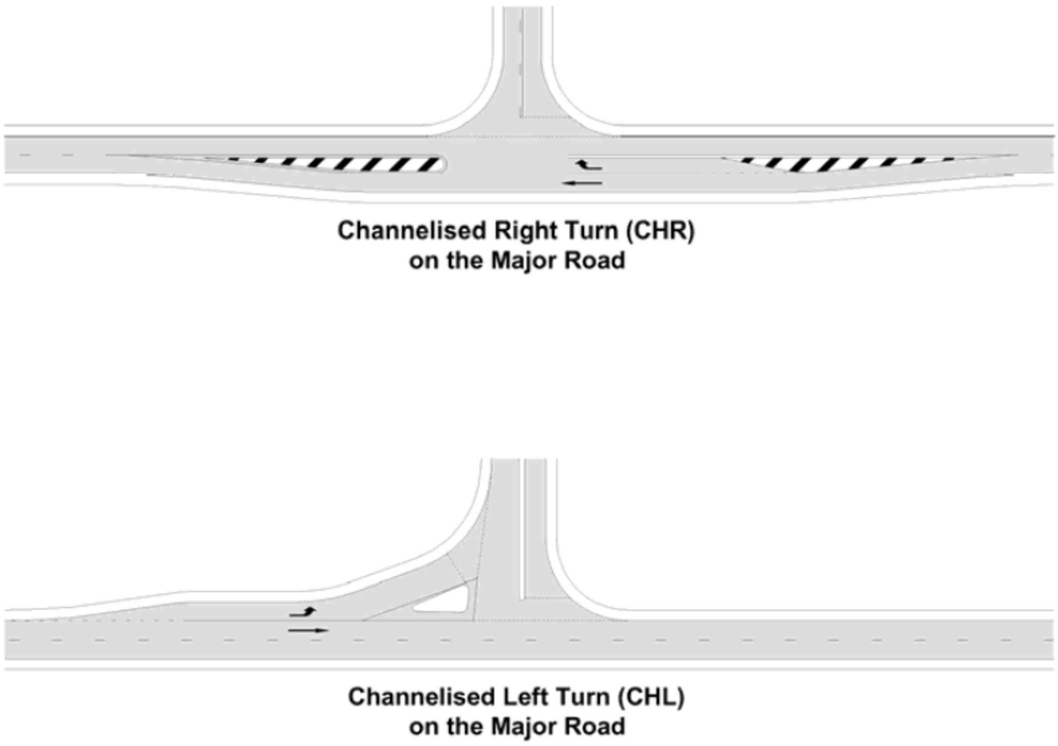

Figure 17-4 Channelised turn treatments (reproduced from Austroads)

17.4.4 Other potential road impacts

Road pavements are normally designed to withstand a certain number of heavy axle repetitions over a certain design life (e.g. 30 years). The addition of 26 vehicles per day over the life of the Nolans Project is significantly less than that added by background growth in that time (depending on the section of Stuart Highway in question). Consequently, it is considered that the Nolans Project will have a negligible impact on the condition of the road surface on Stuart Highway.

It is considered that the addition of 24 vehicles per day (14 vehicles per hour in the peak periods) would be an imperceptible increase that would not limit the ability of members of the public from accessing essential services.

The expected frequency of road closures due to flooding (i.e. twice within an eleven year period, for less than 24 hours) is considered not high enough to significantly affect the transport of materials and personnel to and from the Nolans site.

17.4.5 Contribution to the rail network

The volume of inbound materials to be carried on the Darwin to Adelaide railway is approximately 8,850 TEU (twenty-foot equivalent containers) per annum in total indicated as:

- Quicklime – 1,300 TEU, to be loaded at northern Freight Terminal for transport to Alice Springs Freight Terminal
- Bulk sulfur – 3,900 TEU, to be containerised by the rail operator GWA at Darwin Port or rail terminal and transported by rail to Alice Springs
- Containerised reagents – 1,650 TEU, Darwin Port to Alice Springs
- Containerised reagents and other – 2,000 TEU, Darwin Port to Alice Springs.

RE products Alice Springs to Darwin are included in outbound below. These inbound products are to be transported in intermodal containers or ISO tanks which can be handled with currently available rail resources and lifting equipment.

Bulk sulfur is estimated to arrive in four shiploads per year, assumed to be approximately three months apart. Storage of this product could be at the Darwin Port or the project site and a constant flow of products will generally fit with the use of common infrastructure and rail services on the railway. It is assumed product flows will be at a consistent level with some capability to ramp up or down to best meet transport opportunities.

Outbound rail loadings would be approximately 8,950 TEU per annum including outbound containers to the East Arm Wharf in Darwin and empty containers returning to Darwin and Katherine for the next loads. As this total varies from the indicative incoming task there is likely to be some balancing of containers in line with the month by month task. This variance is minor (two containers per week) and is not likely to alter the general level of demand or impacts. The outbound task is indicated as:

- Empty quicklime containers – 1,300 TEU Alice Springs to northern Freight Terminal for reloading
- Empty sulfur containers – 3,900 TEU Alice Springs Freight Terminal to Darwin Terminal for reloading of bulk materials
- Empty containers local supply – 50 TEU Alice Springs to Darwin
- Intermodal containers – 3,700 TEU Alice Springs to Darwin Port including:
  - RE intermediate products – 2,000 TEU
  - Empty containers/ISO tanks – 1,700 TEU.

17.4.6 Rail capacity impacts

The GWA container trains operate six days a week to Darwin with return journeys on alternative days. The northern loadings to Darwin are quite high but vary according to days of the week and times of the year. The south bound loadings include a number of empty containers and significantly lower tonnages, and allow capacity to cater for many of the needs of the Nolans Project. Intermodal traffic on the line is continuing to grow and GWA is prepared to employ an additional train on Sundays (or other days) if demand increases.

The Nolans rail freight movements of 17,800 TEU per annum for containerised products would add approximately 1,480 TEU per month to the GWA Intermodal task (an increase of approximately 55-60 %), although half of this increase would be on the lightly used return trip southwards from Darwin. The additional rail freight movements heading north from Alice Springs would supplement some empty container slots on the trains where existing containers between Adelaide and Alice Springs are unloaded. There are also likely to be some opportunities to balance the additional loadings on lesser used daily services and increased train size.

The rail corridor allows for passing loops up to two kilometres long and this allows for increases in the length of trains on days where demand is high. An additional train service could add additional capacity in the range of 200 to 250 TEU per trip or in excess of 20,000 TEU per annum based on a weekly return trip, dependent on load type, weight and rolling stock applied. Dependent on other freight loadings, this may be required to accommodate the level of traffic generated by the Nolans Project.

The rail corridor has ample capacity to increase the current number of services and provides capability to increase the train capacity to meet indicated needs.

GWA as the rail network operator requires no further approvals or changes to add services to meet this demand. In addition, the Nolans Project has the option of consolidating loadings from the bulk sulfur imports on specific lower utilised trains (or even a stand-alone train) if required, reducing the regular consistent demand for intermodal services by 44 per cent. This is an option for further detailed discussion with GWA although consolidation may result in the use of additional containers.

The use of the existing rail freight services will not impede the availability of this service for other customers or create a situation of capacity overload on the line. Rather, support for the efficiency of the existing services and the provision of demand which may at some point drive an additional service on a rail corridor with available capacity.

Alignment with road transport

The GWA intermodal trains currently include capacity for a range of ISO and domestic rail based containers and ISO tanks aligned to the needs of the Nolans Project, ensuring that relevant lifting equipment is in place at all locations and all necessary safety and management processes are already in place.

The Darwin Terminal at Berrimah does not currently load bulk materials into containers as a separate service, however, GWA have indicated they are prepared to develop a facility for this need. This enables direct transfer of loaded containers to intermodal trains to Alice Springs. The Nolans transport task will add to the current throughput at some locations but should not impact the needs or practices in terminals and on train.

Loading of quicklime containers at Katherine and unloading on the return journey is directly aligned to current practices and should not alter current operations at this terminal.

17.5 Summary

The Nolans site is located 135 km north-northwest of Alice Springs and approximately 10 km to the west of the Stuart Highway at Aileron Station, NT. Access to the site will be restricted to authorised commercial vehicles only, via a site access road connecting with the Stuart Highway approximately 5 km south of Aileron Roadhouse.

The site access alignment currently exists as an unsealed track, which will be upgraded to a two lane two way sealed road during the construction phase of the project. Project consumables and REO products will be imported and exported respectively from/to Darwin via Alice Springs, using the Darwin to Adelaide railway and the Stuart Highway.

Based on the quantity of consumables required to be imported, the trip generation of the site is expected to be an average of 26 daily one-way-trips. The forecast total daily generation of 26 vehicles and peak hour generation of 16 vehicles indicate that operations at the site are likely to result in low impacts on the existing road network.

An assessment of the requirements for the intersection of the site access road with the Stuart Highway indicates that basic auxiliary left/right treatments would be sufficient from a traffic capacity perspective. However, it is considered that the open speed limit on this section of the highway warrants a channelised treatment from the Stuart Highway into the site access road to improve road safety.

It is concluded that the Nolans Project will have minimal impacts on the existing road network (including on the road pavement and the ability of the public to access essential services). No upgrades or modifications are required to support the Nolans development, aside from the upgrade of the site access intersection with the Stuart Highway.

It is further concluded that the rail transport task will not adversely impact capacity on the Alice Springs to Darwin rail freight line, nor will it impede the availability of existing services to other users.

18

Rehabilitation, decommissioning and closure

18. Rehabilitation, decommissioning and closure

18.1 Introduction

This chapter describes the potential impacts from the rehabilitation, decommissioning and closure of the Nolans mine site on the surrounding environment. A detailed conceptual mine rehabilitation and closure plan (MRCP) is provided in Appendix W of the EIS.

The TOR for the preparation of an environmental impact assessment issued by the NT EPA for the project provided the following environmental objectives in relation to the rehabilitation, decommissioning and closure of the Nolans mine site:

- *As far as practicable, rehabilitation will achieve a stable and functioning landform which is compatible with the surrounding landscape and other environmental values.*
- *Potential impacts to downstream water quality / potable-water supplies, ecosystems, beneficial uses, environmental / cultural values or human health, associated with closure and rehabilitation of the Project will be identified, and adequately avoided, mitigated and/or minimised.*
- *Rehabilitation of areas impacted by mining, will ensure:*
  - *Health risk to members of the public, including traditional owners, will be as low as is reasonably achievable.*
  - *Members of the public will not receive a radiation dose which exceeds applicable limits recommended by the most recently published, relevant Australian standards, codes of practice, and guidelines.*

This chapter addresses the potential impacts resulting from the closure of the Nolans mine. This includes closure timeframes, risks of ongoing environmental, social and/or economic legacy, natural events, including earthquakes, rainfall events, fire and flood, as required in the TOR for the project.

18.2 Approach to mine closure

Planning for rehabilitation, decommissioning and closure for the whole of project has been initiated as a conceptual process and will be refined as the project progresses through detailed design and construction.

The overriding intent of mine closure and rehabilitation is to return the land to as close as is reasonably practical, its pre-disturbance condition. This will be achieved through establishment of a safe and stable post-mining land surface which supports vegetation growth and is erosion resistant over the long-term.

The objectives of mine closure and rehabilitation are:

- To establish a safe and stable post-mining land surface which supports vegetation growth over the long-term
- To return the land, as close is reasonably practical, to its pre-disturbance land use
- To make the site suitable for future leaseholders likely uses for the site.

The Northern Territory DME requires that a post mining land use is discussed with all stakeholders and agreed to by the Department, and that this process should be recorded in the earliest planning documentation for the site.

To date, no commitments have been made by Arafura to third parties in relation to the closure of the Nolans Project. As the project proceeds through the approval process and (presumably) into construction and operation, a mine closure commitments and obligations register will be prepared and maintained that will record progress towards fulfilment of this requirement.

This chapter should be read in conjunction with the Mine Rehabilitation and Closure Plan (MRCP) provided in Appendix W, which details the mine closure domains and describes the key closure landform concepts.

The MRCP is designed to take into consideration the legal obligations, best practice and environmental risks associated with the Nolans mine project.

18.2.1 Post closure land uses and completion criteria

Post closure land use will be balanced, with the target ecosystems and pre-mining land use and land condition identified in the EIS flora and fauna technical reports (Appendix M and Appendix N). Targets for rehabilitation will be native flora species. The target ecosystems will evolve with the post-closure rehabilitation planning and the results of rehabilitation trials.

The final, post-closure land use will be developed and refined through the operating life of the mine. Various factors will influence its development (as described in detail in Appendix W) including:

- Consultation with stakeholders
- Post-Closure Land-use Alternatives Assessment undertaken in parallel with consultation
- Emerging knowledge of the nature of the deposits, and the composition and quantity of waste products and
- Any future changes to mine design.

Completion criteria provide a means of evaluating the successful achievement of the closure objectives. The level of detail of completion criteria will be appropriate to the stage of development. The conceptual closure plan described in Appendix W is submitted pre-approval, and further detail and definition will be added to the criteria during Project design, construction and during operations.

Specific performance indicators will be determined to demonstrate that rehabilitation trends are following the predicted performance, particularly where mathematical modelling is utilised to predict any long term environmental impact. In agreement with the regulators, the criteria may be reviewed and amended in response to operational and post-closure management and monitoring programmes.

18.2.2 Risk assessment

The risks associated with closure, rehabilitation and post mining land use were examined as part of a risk assessment undertaken for the Nolans Project. This process was completed in accordance with the requirements outlined in *Australian Standard AS/NZS ISO 31000:2009 Risk Management* and *HB 436:2004 Risk Management Guidelines*. The methodology for this process is described in Chapter 5 and Appendix F.

18.3 Key closure risks

Table 18-1 summarises the risks arising from the closure of the Nolans mine site and the potential impacts on environmental, social and economic receivers that may arise from this activity. The level of risk is residual risk following implementation of controls. Controls incorporated into the design of the mine site are discussed in Section 18.5 with further mitigation measures required to minimise any residual impacts.

Table 18-1 Closure risks and potential impacts

Potential closure risks	Potential environmental and socio-economic impacts	Level of residual risk (from Appendix F)
Decommissioning and closure		
Unexpected early closure	Unanticipated events could result in unplanned closure before adequate closure and rehabilitation planning and design is in place, resulting in ineffective or incomplete rehabilitation, including: Contaminated seepage Loss of containment of hazardous materials Failure to achieve proposed closure land uses and target ecosystems.	Medium
Insufficient funds / bonds for closure activities	Inadequate closure designs, poor assumptions or failure to recognise impact of changes to operations on MRCP results in insufficient bonds or funds on closure; causing delays to effective rehabilitation and potential ongoing environmental hazards.	Low
Operational practice creates difficult to manage waste facilities during closure	Failure of operational process (e.g. neutralisation prior to RSF disposal, maintenance of containment facilities, partitioning of radionuclides) leaves a legacy of difficult to manage waste facilities during closure resulting in: — Impacts associated with rehabilitation failure or post-closure emissions — Costly and complex remediation — Delays to effective rehabilitation — Cost overruns.	Medium
Insufficient cover material available on closure	The lack of availability of suitable low permeability material on site, or prohibitive cost of importing large volumes from elsewhere, prohibits the creation of proposed capping for TSF and RSF preventing long term stabilisation and containment of waste.	Medium
Ineffective closure designs and execution	Closure not implemented satisfactorily due to: Closure designs not being developed to sufficient detail or based on incorrect assumptions; and Poorly managed execution of closure works. This may result in the failure of post-closure landforms and waste containment, extensive cost overruns, delays to relinquishment, damage to reputation.	Medium

Potential closure risks	Potential environmental and socio-economic impacts	Level of residual risk (from Appendix F)
Incomplete removal of infrastructure	Incomplete removal of equipment, structures, hardstand and concrete footings, buildings, water storages created health and safety hazards for future land users.	Low
Incomplete remediation of contaminated sites	Contamination resulting from operations is not remediated to an agreed level, resulting in: • Harm to the health of flora and fauna • Harm to public health including that of future land users and/or • Failure of effective rehabilitation.	Medium
Environmental impacts from closure activities	Closure activities are poorly managed leading to impacts on local communities, flora, fauna, water resources, such as: • Noise and Vibration • Light • Dust • Unnecessary damage to vegetation • Spreading of weeds • Contamination of surface water or groundwater.	Medium
Landscape and ecological rehabilitation		
Rehabilitation failure due to rehabilitation design / execution	Rehabilitation fails to achieve sufficient vegetation to stabilise ground, allow proposed land uses or achieve target ecosystems, due to inappropriate design or execution of rehabilitation, including: • Inappropriate planting strategies, seed mix etc. • Inappropriate distribution growth medium • Inappropriate landform design • Inappropriate post-closure drainage.	Medium
Rehabilitation failure due to post-closure conditions	Rehabilitation fails to achieve sufficient vegetation to stabilise ground, allow proposed land uses or achieve target ecosystems, due to extreme events (i.e. natural events such as bushfires, drought or flood), uncontrolled grazing by wildlife, pests or livestock or unsuitable post closure conditions.	Low
Weed infestations prevent achievement ecosystem targets for rehabilitation	Weed infestations created or exacerbated by operation or closure activities lead to failure to achieve ecosystem targets for rehabilitation.	Low

Potential closure risks	Potential environmental and socio-economic impacts	Level of residual risk (from Appendix F)
Failure of recovery of fauna populations including those of threatened species, to recover to pre-project levels	Failure to achieve fauna habitats within target ecosystems due to: • Weed infestation • Wildlife ingestion or exposure to radioactive due materials to airborne deposition of dust or waterborne sediment • Increase in pest animal species (cats, rabbits, foxes, rats, mice) • Wildlife ingestion or exposure to supernatant material in pit lake.	Low
Post-closure releases or emissions		
Seepage of site contaminants impacting surface and to groundwater quality	• Seepage from site contamination, TSF, WRD and RSF causing loss of surface and groundwater quality • Risk of post closure impacts on groundwater quality from WRD seepage is low. TSF tailings seepage composition is expected to mirror that of the WRD and are also not expected to result in adverse groundwater impacts, particularly given the liner systems proposed (below) • Leaching from land contaminated during operation and from an on-site landfill could result minor localised in release of harmful material if not correctly rehabilitated • Existing groundwater has elevated levels of metals, salt and fluoride and if expressed to surface and allowed to concentrate through evaporation may result in waters with potentially harmful concentrations of salt, metals and radionuclides.	Medium
Contaminated runoff	Low rainfall and very high evaporation rates mean that site drainage is ephemeral and impacts on surface water quality will only occur during flood events when sediment levels will naturally by elevated and dilution of harmful contaminants. In these instances, the closed site becomes an ongoing source of surface water pollution, as a result of: • Accelerated erosion and sedimentation resulting from unstable soils and landforms or failure to contain hazardous materials • Seepage from waste facilities and concentration by evaporation at surface.	Low
Dust	Dust emissions caused by post-closure wind erosion and transport of wind-borne material may cause: • Exposure of wildlife, livestock and humans to toxic metal compounds • Exposure of future users of the site and local communities to fine particulate dust (TSP and PM10) with impacts to human health • Vegetation dieback from dust deposition • Degradation of surface water quality • Nuisance dust for surrounding communities.	Low

Potential closure risks	Potential environmental and socio-economic impacts	Level of residual risk (from Appendix F)
Radiation from post closure sources	The credible consequence to human health and safety of public located at nearby off-site receptor, is the potential for measurable increase to radiation exposure, up to 1 m/Sv per year. Exposure to radiation from post-closure sources may occur through the following routes: direct irradiation, inhalation or ingestion.	Low
Long-term Sustainability		
Long term landscape instability	Rehabilitated landscape experiences long term higher erosion rates, reduced vegetation cover and slope instability reducing the life of waste cover systems leading to exposure and mobilisation of hazardous waste materials. Exacerbation by long term climate change resulting in more frequent and extreme storm events droughts and bushfires.	Low
Groundwater recharge rate is slower than expected	Overuse of groundwater during operation, changes to the groundwater regime caused by drawdown from evaporation at pit lake, and / or changes to recharge rates due climate change result in slower than predicted aquifer recovery. This could result in: • Decline in availability of water to ecosystems, including riparian vegetation associated with Day Creek with downstream impacts to Lake Lewis • Loss of future availability of water resource from the Southern basins borefield • Water table drawdown in the Ti Tree or basins associated with Alice Springs water supplies from the cumulative effect of the Southern basins borefield and mine dewatering • Ongoing impact on water dependant cultural heritage sites from dewatering.	Medium
Long term risks from hypersaline pit lake	Contaminants in groundwater are concentrated by evaporation from the pit lake post closure, resulting in elevated concentrations of harmful materials and then become mobile through: • Animal ingestion • An extreme event resulting in a flood release • An unexpected increase in hydraulic conductivity (e.g. preferential pathways or large fractures not identified during initial assessment) • A density-driven flow where sinks leak into surrounding aquifers and offer a potential pathway.	Low
Stakeholder and social impacts		

Potential closure risks	Potential environmental and socio-economic impacts	Level of residual risk (from Appendix F)
Public access to harmful areas of Nolans site during and post-closure	Unauthorised site access / security breach during closure, leading to exposure of the public to hazards and risking ill health, injury or death. Plant and/or equipment contaminated with ore or process materials leaving the site while still contaminated with radioactive or other hazardous material resulting in off-site radioactive or chemical contamination resulting in harm to the public.	Medium
Failure to agree post closure land use	The future uses proposed by the MRCP are not accepted by DME or stakeholders resulting in delays to approvals.	Low
Failure to achieve approved post closure land use	Post-closure site does not conform to regulator and stakeholder expectations for land-use, leading to DME not accepting relinquishment and associated rehabilitation costs and ongoing liability.	Low

18.4 Closure implementation

The Mine Management Plan (MMP) will establish a system by which environmental impacts are managed during operation, including maintaining the site so it can be closed and rehabilitated practicably and without creating additional environmental impacts.

Key elements of operational management that will contribute to closure are:

- Acid Metalliferous Drainage Plan (Appendix L).
- Process Plant Process Controls, especially multi-stage neutralisation process (pH control);
- A Tailings Management Plan for tailings and residue deposition to support closure will include:
- Site management plans (Appendix X) including the ESCP, Weed and biodiversity Management Plans.

18.4.1 Closure and rehabilitation implementation timetable

Table 18-2 provides an indicative timeline of the phases of closure and rehabilitation planning, implementation and monitoring. The program is provisional and may be subject to change resulting from a wide range of potential factors. The program will be reviewed and updated regularly during the life of the project.

A number of pre closure trials and investigations will be carried out during the operational life of the mine, and the results will be used to inform final landform design and rehabilitation proposals. Trials will include:

- Progressive Rehabilitation trials
- Rehabilitation and closure materials
- Tailings Storage Facility Covers and Rehabilitation
- Waste management
- Geochemical studies
- Radiological testing
- Groundwater Resources
- Long Term Pit Lake Behaviour
- Ecology and Weeds and
- Soil Contamination.

Table 18-2 Closure implementation timetable

Phase	Timetable	Summary of activities	Closure Plan	Closure and Rehab Designs	Closure Costs
Approvals	Pre-operation	Initial Closure Planning and Design.	Preliminary MRCP and Initial stakeholder engagement and Post-Closure Land-use Alternatives Assessment.	Closure Concept (Appendix W).	Conservative preliminary closure costs prepared before operation.
Operation	1st year of operation	Detailed Closure Planning and Design.	First Draft detailed MRCP First Draft detailed Care and Maintenance Plan and Stakeholder agreed post closure land uses.	Outline closure design and Conservative waste storage to cope with early closure.	Prepare robust closure costs estimate in the first year of operation.
	43 years based on current LOM	Progressive rehab of TSF, RSF, WRD; and Vegetation and cover trials.	Annual review of MRCP; Trials, investigations and monitoring; and Regular review of risk assessment and MRCP.	Annual review of closure and rehab designs; Progressive rehabilitation; and Iterations to designs with new innovations in closure design emerging data and amendments to mining plans and activities.	Annual review of costs in response to updated designs and MRCP.
Pre-Closure	5 years pre- closure	Seeding of closure vegetation; Develop tender documents and procure contractors for closure activities; and Pre closure surveys	Final detailed closure plan; Pre-closure surveys; and Closure Waste Management Plan.	Finalised closure design.	Finalised costs.
Decommissioning and Closure	2 years post closure	Capping / covering of TSF, RSF, WRDs; Removal of evaporation / event ponds; Removal of project infrastructure components; Remediation of contaminated land;	Full implementation of MRCP; Annual review of MRCP; and Audit of closure completion.	Designs implemented; and Audit of design implementation.	

Phase	Timetable	Summary of activities	Closure Plan	Closure and Rehab Designs	Closure Costs
		Creation of closure landforms; and Decommission / closure of borefield.			
Rehabilitation	5 years post closure	Soil conditioning and planting and Weed and fire control.			
Post Closure	10 years post closure	Weed and fire control; and Monitoring and maintenance of rehabilitation areas			

18.4.2 Planning for closure

Responsibilities

The MMP will establish a system to manage environmental impacts during operation, including maintaining the site in a form that can be closed and rehabilitated practicably and without creating additional environmental impacts.

During operation the Mine Manager will have responsibility for the development of the mine closure plan, designs and costs as well as ongoing closure related activities such trials, monitoring, progressive rehabilitation.

Specialised contractors will be used for the decommissioning where required. In the final year of mining, tender documents will be prepared and procurement will be programed for completion before the closure date, so that decommissioning commences as soon as possible after the end of production.

Arafura is responsible for ensuring that there are adequate resources available for rehabilitation, particularly for the premature closure of the mine.

Post-closure maintenance

Where monitoring identifies failure to meet completion criteria or trends that are likely to result in a failure to meet the criteria, the causes will be investigated and if possible, maintenance determined and implemented.

Post-closure reporting

Reports detailing the monitoring results will be issued annually to DME for the 10 year period post closure. The reports and monitoring are to be undertaken by suitably qualified individuals and provided to the relevant governing authorities.

The completion criteria and monitoring programme may change as research and development findings and monitoring trends emerge.

Rehabilitation audit

Prior to the relinquishment a rehabilitation audit will be undertaken to assess the achievement of the completion criteria. The results will be issued to DME who will determine whether the site can be relinquished.

18.5 Mitigation and monitoring

Prior to closure the MRCP (including the following sub plans), will be reviewed to include potential impacts to the environment due to closure activities and update the control measures:

- Air and noise management plan
- Biodiversity management plan (including the pest animal management plan)
- Hazardous substances management plan
- Radiation management plan
- Radioactive waste management plan
- Transport management plan
- Water management plan
- Closure waste management plan

- Weed management plan
- Tailings management plan
- Erosion and sediment control plan
- Operation of an environmental management system including a system for the reporting of spills and maintaining a contaminated sites register and
- Prior to closure the safety management system will be reviewed and updated to include potential hazards and risks associated with closure activities.

18.5.1 Decommissioning and closure

A summary of the mine closure mitigation measures is provided below to address the key risks outlined in is Table 18-1. More detail is provided in Appendix W.

Table 18-3 Closure risks and mitigation measures

Potential closure risks	Potential environmental and socio-economic impacts
Decommissioning and closure	
Unexpected early closure	The site will be designed and operated to be ready for closure iteratively through the operational life of mine.
Insufficient funds / bonds for closure activities	Closure costs will be developed iteratively throughout the operational life of the mine. A bond will be agreed and issued to NT Government, and reviewed annually.
Operational practice creates difficult to manage waste facilities during closure	A waste management plan will be developed prior to closure which will identify the waste stream, proposed treatment and disposal destination.
Insufficient cover material available on closure	A preliminary mass balance will be created for the critical volume of the growth medium requirement based on the current mining plan, geotechnical and geochemical data. Clean inert waste rock will be available in significant volumes for closure works. Detailed specifications for closure materials will be developed in a detailed MRCP in the first year of operation.
Ineffective closure designs and execution	Prepare detailed closure designs as part of iterative closure design development program, costing and good practice requirements.
Incomplete removal of infrastructure	Pre demolition surveys and contaminated land surveys of plant and infrastructure will be completed with works undertaken by a suitable demolition contractor. Options for reuse, recycling and waste disposal for used plant will be investigated.
Incomplete remediation of contaminated sites	a process of assessment, remediation planning and design will be implemented prior to closure. An independent audit of the remediated site will be completed.
Health and safety risks to personnel during closure	Prior to closure the health, safety and environmental management systems employed during operation will be reviewed and updated to include potential hazards and risks associated with closure activities and will remain in force while activities continue at the site.
Environmental impacts from closure activities	Prior to closure the mine management plan will be reviewed and updated to include potential impacts due to closure activities.
Landscape and ecological rehabilitation	

Potential closure risks	Potential environmental and socio-economic impacts
Rehabilitation failure due to rehabilitation design / execution	Waste rock dumps will remain on the surface rather than be backfilled into the pit and will be progressively rehabilitated. This is a key component of the rehabilitation strategy for the Project and will be integrated into the MRCP.
Rehabilitation failure due to post-closure conditions	Concept level closure and rehabilitation proposals will include appropriate drainage and erosion control, land management controls (i.e. grazing, fire management) and will employ conservative design. .
Weed infestations prevent achievement ecosystem targets for rehabilitation	Weeds will be monitored and controlled through the mine management plan during the operational phase. A full weed survey of the site will be undertaken pre-closure. The operational weed management plan will be reviewed and updated before closure.
Failure of recovery of fauna populations including those of threatened species, to recover to pre-project levels	Prior to closure, the pest animal management plan will be reviewed and updated to incorporate specific control measures for closure and rehabilitation, including monitoring of feral species numbers around the Nolans site and fauna activity at the pit lake.
Post-closure releases or emissions	
Seepage of site contaminants impacting surface and to groundwater quality	Prior to closure, review and update the AMD management plan to incorporate specific control measures for closure and rehabilitation. Implement a groundwater monitoring program through the closure phase. Prepare detailed closure designs including lining and capping details and management of potentially acid forming waste rock
Contaminated runoff	All water storages and tailings will be designed to an appropriate ANCOLD risk category and relevant design standards for the provision of adequate storage capacity. Sufficient freeboard allowance will be maintained to prevent overflow from TSF or RSF during predictable high rainfall conditions.
Dust	Prior to closure the dust management plan will be reviewed and updated with specific control measures for closure and rehabilitation and implement post closure. The waste rock dump, TSF and RSF will be designed with appropriate containment (cover / capping and liners) and the landform surfaces will be stabilised by re-vegetation.
Radiation from post closure sources	Prior to closure, relevant plans will be updated to incorporate specific control measures for closure and rehabilitation. Suitable containment of waste will be ensured, access to the pit and pit lake will be restricted
Long-term Sustainability	
Long term landscape instability	Past climatic data will be analysed and likely future climate scenarios modelled to identify likely drought conditions to be faced by the rehabilitated site to ensure the proposed rehabilitation systems can cope with a full range of likely conditions.
Groundwater recharge rate is slower than expected	The groundwater model will be recalibrated during the mines operational life and current and potential future users will be identified in advance of closure in order to develop ground/surface water management strategies. Substitute water sources from elsewhere will be provided for existing stock bores if required. Groundwater bores will be monitored during the post closure phase. All project bores will be decommissioned at closure.
Long term risks from hypersaline pit lake	Post closure landforms and drainage will be designed to ensure runoff and seepage directed to the pit is low enough to ensure evaporation of surface water. Inflow to the pit lake will be managed to keep the lake below the surrounding groundwater level, preventing outward flow of groundwater or surface discharge. Model scenarios should be

Potential closure risks	Potential environmental and socio-economic impacts
	run for an appropriate time period (which could be up to 10,000 years), commensurate with the risk of the pit lake, which could be until a geochemical equilibrium is reached.
Stakeholder and social impacts	
Public access to harmful areas of Nolans site during and post-closure	In addition to stakeholder and community engagement during closure, access restrictions and security management will be undertaken. Emergency response procedures, team and equipment will be provided during closure.
Failure to agree post closure land use	Stakeholders will be consulted throughout the life of mine and feedback will be incorporated into the post-closure land-use alternatives assessment.
Failure to achieve approved post closure land use	A continuous stakeholder engagement and communications plan will be developed for informing local and regional communities and other stakeholders of closure planning processes. This will include agreeing on post-mining land uses, closure objectives, completion criteria and implementation strategies.

19

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19. References

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