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Abbreviations

Abbreviations

Term	Description
µg/m^3	Micrograms per cubic metre
µGy/h	Micrograys per hour
µJ/m^3	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

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

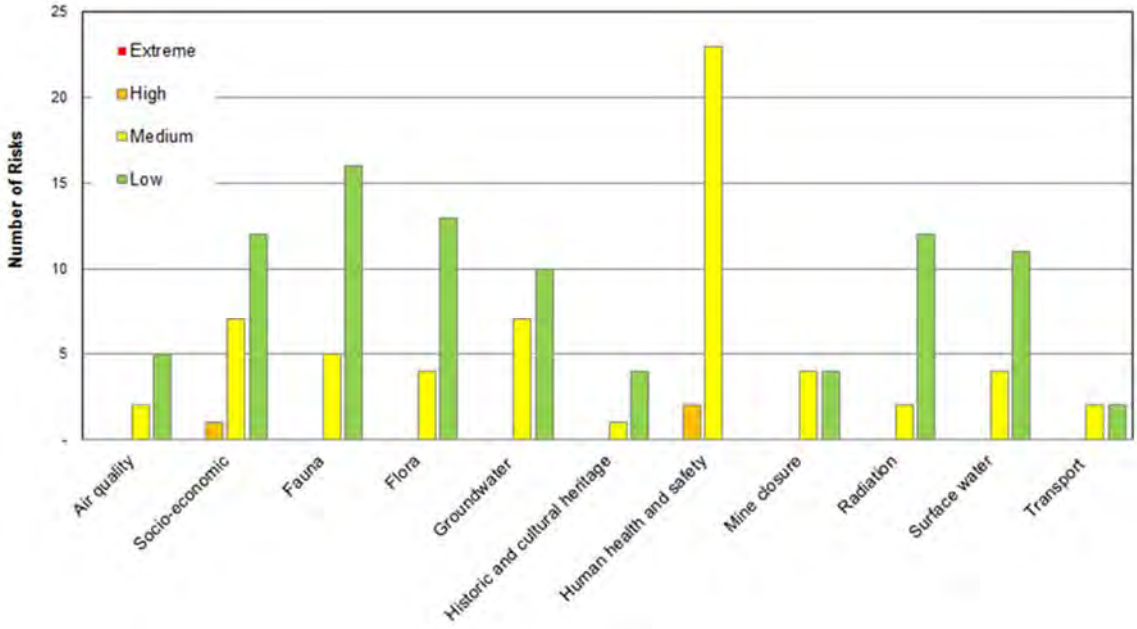
The EIS has been undertaken with a specific emphasis on the identification, analysis and mitigation of potential environmental risks. The risk assessment approach provides a framework for identifying components of the project with the potential for greater environmental risk and highlights project specific 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.