7 February 2019

Dear reader,

It is with great pleasure that I present to you the results of Arafura's definitive feasibility study (DFS) on Arafura's Nolans Neodymium-Praseodymium (NdPr) Project in the Northern Territory.

The DFS has confirmed Nolans as a financially and technically robust project that will support a long-life mining operation and a globally strategic asset that will become a significant world-scale supplier of NdPr.

The project unlocks the unique geology of the Nolans deposit using a combination of phosphate and rare earth extraction processes to produce an average annual production of 4,357 tonnes of NdPr oxide, 21% higher than previously expected, and 135,808 tonnes of merchant grade phosphoric acid over an initial mine-life of 23 years.

The outstanding result from the study is the ultra-low operating cost of US$25.94/kg of NdPr oxide placing Arafura firmly in the lowest cost quartile for NdPr operations globally. Nolans delivers average EBITDA of A$377 million per annum and carries an NPV of A$729 million using a 10% discount rate. The project IRR is estimated at 17.43%.

The DFS uses a modest base case assumption for the NdPr oxide selling price in the range of US$67 to US$90 per kilogram across the life of mine. Demonstrating how leveraged Nolans is to the NdPr oxide price, each US$5/kg increase adds A$130 million to the NPV.

Pre-production capital expenditure for the project has been estimated at A$1,006 million (US$726 million) including A$110.4 million of contingency. The project also benefits from being fully located in Australia thereby minimising sovereign risk and providing valuable employment opportunities for indigenous and non-indigenous Australians. The project has been afforded 'major project status' from the Northern Territory Government and Australian Government.

Arafura was assisted in the preparation of the DFS by world-leading and reputable specialist consultants including:

- Hatch – Process plant, infrastructure and lead study engineer;
- Mining Plus – Mine planning and Ore Reserves;
- Knight Piésold – Tailings Storage Facility design, geotechnical and surface water management;
- GHD – Hydrogeology and water supply studies, environmental;

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- Qube Bulk – Logistics study;
- AMC Consultants – Mine geotechnical study;
- Roskill Consulting Group – Market analysis, rare earths;
- CRU International – Market analysis, phosphoric acid.

The Company will now focus its attention on the next phase of development including finalising offtake agreements, completing financing and commencing construction of the world's most significant NdPr development projects in a premier mining jurisdiction.

We continue to target project commissioning in early to mid-2022.

I thank you for your interest and ongoing support.

Kind Regards,

Gavin Lockyer
Managing Director

Arafura Resources wishes to thank all contributors to the Nolans Definitive Feasibility Study

ARAFURA RESOURCES LIMITED

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Australia

NOLANS PROJECT

Definitive Feasibility Study

Summary Report

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COMPETENT PERSON’S STATEMENT

The information in this Report that relates to Exploration Results or Mineral Resources is based on information compiled by Mr Kelvin Hussey (BSc (Hons), FGS), a Competent Person who is a Member of the Australian Institute of Geoscientists (MAIG). Mr Hussey is a full-time employee of Arafura Resources Limited. Mr Hussey has sufficient experience that is relevant to the style of mineralisation and type of deposit under consideration and to the activity being undertaken to qualify as a Competent Person as defined in the 2012 Edition of the Australasian Code for Reporting of Exploration Results, Mineral Resources and Ore Reserves. Mr Hussey consents to the inclusion in this Report of the matters based on his information in the form and context in which it appears.

The information in this Report that relates to Ore Reserves is based on information compiled by Mr David Billington, BEng (Mining), a Competent Person who is a Member of the Australian Institute of Mining and Metallurgy (MAusIMM). Mr Billington is a full-time employee of Mining Plus Pty Ltd. Mr Billington has sufficient experience that is relevant to the style of mineralisation and type of deposit under consideration and to the activity being undertaken to qualify as a Competent Person as defined in the 2012 Edition of the Australasian Code for Reporting of Exploration Results, Mineral Resources and Ore Reserves. Mr Billington consents to the inclusion in this Report of the matters based on his information in the form and context in which it appears.

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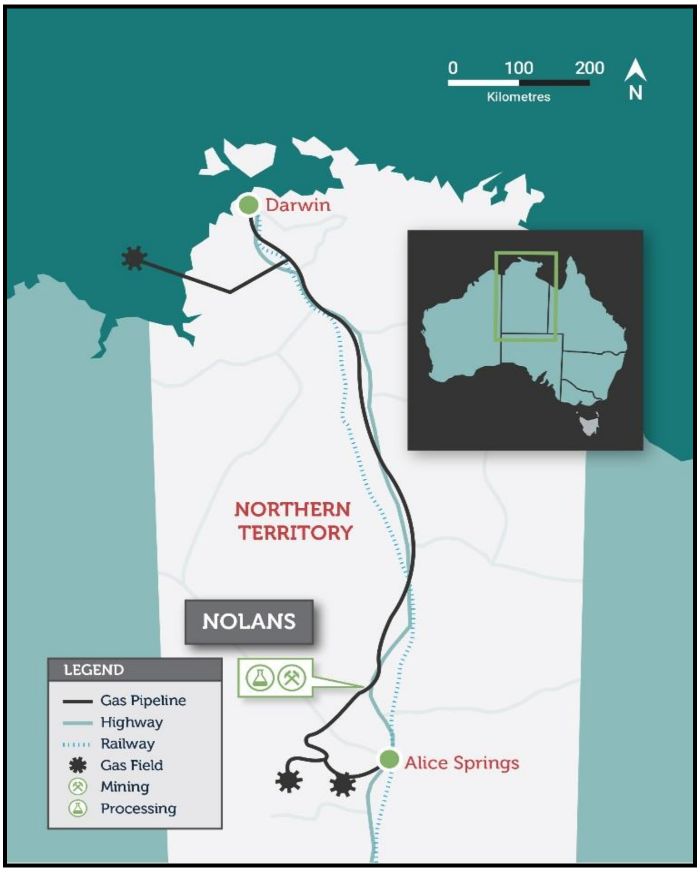
1 INTRODUCTION

This executive summary provides an overview of Arafura Resources Limited's (Arafura or the Company) definitive feasibility study (DFS) for its wholly-owned Nolans Rare Earths Project (Nolans or the Project). The Project will encompass a mine, process plant and related infrastructure to be constructed and located at the Nolans site in Australia's Northern Territory (Figure 1). The Project is underpinned by a low risk mineral resource that has the potential to supply up to 10% of the world's rare earths demand.

Figure 1
Nolans Project Location



The Project will produce three rare earth products and merchant grade phosphoric acid (MGA) for sale to customers globally.

The majority of the Project revenue will be generated by neodymium and praseodymium (NdPr) oxide which feed the highest value segments of the rare earth market with the strongest demand outlook. NdPr oxide is in high demand from alloy and magnet producers and the Nolans deposit is highly enriched in NdPr. NdPr oxide sales are forecast to comprise over 85% of the Project's revenue.

MGA phosphoric acid is produced as a by-product from processing phosphate-rich minerals in the ore body and represents a revenue credit against operating costs which ensures the Project is positioned as a low-cost NdPr oxide producer.

The DFS has determined that the Project's flowsheet is technically feasible and economically viable to treat Nolans ore. Arafura can position Nolans as a viable long-life, low-cost alternative supplier of NdPr oxide, located in a jurisdiction with low political risk.

Key Project information is summarised in Table 1.

Table 1 Key Project Information		
Total Mineral Resources (contained REO)	Mt	1.45
Measured and Indicated Resources (contained REO)	Mt	0.97
Total Ore Reserves (contained REO)	Mt	0.57
Annual NdPr Oxide Production*	tpa	4,357
Annual Phosphoric Acid Production*	tpa P_2O_5	73,336
Mine Life – Ore Reserves	Years	23
Preproduction Capital Cost, including Contingency	A$M	1,006
Operating Costs (average*)		
Mining	A$M/a	43
Processing	A$M/a	148
General and Administration	A$M/a	21
Total Operating Cost*	A$M/a	212
EBITDA (average)	A$M/a	377
Operating Cost per kg NdPr Oxide net of Phosphoric Acid Credit*	US$/kg	25.94
Net Present Value (after tax with 10% discount rate)	A$M	729
Internal Rate of Return	%	17.43
Payback	Year	5
Engineering, Design, Construction & Commissioning	Months	30

* Average production and costs are calculated as the arithmetic annual average following the anticipated three year ramp up period and excluding the partial final year of production.

The Company's evaluation of the Nolans Project indicates that it is financially robust and that it should provide a strong return on investment.

1.1 Project Overview and Key Outcomes

The Project site is well located with respect to transport, energy and water infrastructure, being 135 kilometres north of Alice Springs and 10 kilometres west of the transnational Stuart Highway. Alice Springs is well served by modern road, rail, air and telecommunications infrastructure.

The Amadeus Gas Pipeline passes through the Project site with sufficient supply of natural gas for direct and indirect firing of process equipment and to generate power for the Project.

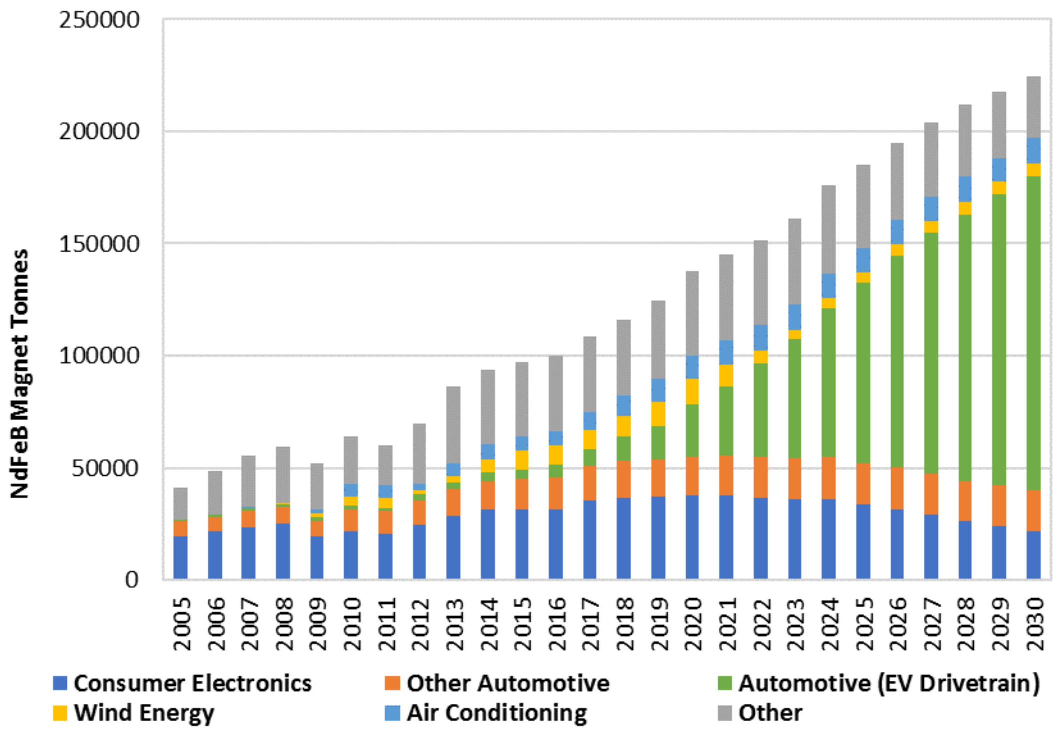
Arafura has identified a sustainable groundwater resource approximately 25 kilometres southwest of the process plant site to service the Project's operational needs.

Product Marketing

The use of rare earths, primarily NdPr oxide, in the neodymium iron boron (NdFeB) magnet sector represents the largest rare earth application, accounting for 26% of use. NdFeB magnets have very high magnetic strength for their mass and are the preferred drive train technology in electric vehicles (EV). Growth in demand for NdFeB magnets is attributed to increased use in the automotive industry, in particular electric traction drive trains, and the forecast worldwide expansion of EVs. Magnet use in EV drive trains is forecast to increase from less than 10% in 2018 to account for 62% of NdFeB magnet demand by 2030 (Figure 2).

Figure 2

NdFeB Magnet Consumption and Demand by End Use



An independent marketing report by Roskill highlights the emergence of a substantial NdPr oxide supply gap by the mid-2020s. Global NdPr oxide supply in 2018 was 37,000 tonnes which needs to expand to 61,800 tonnes over the coming decade to meet forecast demand. At the same time, the proportion of illegal and undocumented Chinese supply is forecast to reduce from 27% to 14% over the next decade through continued government inspections and closure of illegal mining and processing operators.

NdPr oxide prices have improved from an average of US$39 per kilogram in 2016 to US$50 per kilogram in 2018. The gradual long-term upward trend in NdPr oxide prices is likely to continue, driven by macroeconomic and geopolitical events, environmental cost increases and stronger global demand for NdFeB magnets. China's enforcement of rare earth policy will place further pressure on supply, the exports of rare earths and coupled with strong internal demand, could see China become a net importer of NdPr oxide in the future.

The major by-product from the Project, MGA phosphoric acid, is predominantly used in fertilizer production. The market expanded at a CAGR of 2.0% during 2012-2017. Key drivers for phosphate fertilizer demand include population growth, rising income levels and resource constraints which impacts the need for increased agricultural productivity. Population growth and rising income levels in China and India will be significant drivers for increased food consumption and a flow on increase in demand for MGA phosphoric acid.

The majority of global phosphoric acid production (45 Mt of contained P_2O_5 in 2017) is not available for trade and consumed by integrated fertilizer plants. In 2017, only 4.4 Mt of phosphoric acid (P_2O_5) was traded, with India's consumption accounting for approximately 50%. An independent marketing report prepared by CRU indicates that demand for phosphoric acid is anticipated to remain strong for the foreseeable future.

Geology and Resources

Significant exploration has been carried out on the Nolans Bore deposit since its acquisition by Arafura in 2001. Arafura has completed more than 100 kilometres of drilling, together with significant mapping and geophysical surveys to delineate the resource. The deposit has been systematically drilled to a depth of approximately 215 meters below surface at a 40 metre by 40 metre spacing with localised areas of 20 metres by 20 metres. Mineralisation remains open at depths beyond 400 metres.

Mineral Resources were announced on 7 June 2017 and are classified according to the 2012 JORC Code guidelines Table 2.

Table 2
Statement of Mineral Resources for the Nolans Bore Rare Earth Deposit
Announced 7 June 2017 – 1% TREO lower cut-off grade

Category	Tonnes (Mt)	TREO (%)	P_2O_5 (%)	NdPr Enrichment (%)
Measured	4.9	3.2	13	26.1
Indicated	30	2.7	12	26.4
Inferred	21	2.3	10	26.5
Total	**56**	**2.6**	**11**	**26.4**

Note: Numbers may not compute due to rounding. "NdPr Enrichment" is the proportion of TREO comprising neodymium oxide Nd_2O_3 and praseodymium oxide Pr_6O_{11}.

Mining and Ore Reserves

The Project's Ore Reserves, which support a 23-year mine life, has been estimated following pit optimisations based on the relevant modifying factors.

Mining will be carried out using typical drill and blast operations, hydraulic excavator(s) and rear dump trucks. The strategic mining schedule is based on an average mining rate for the first seven years of 3.2 Mt per annum, average over the duration of mining of 7.6 Mt per annum, with a maximum rate of 11.2 Mt per annum. Ore from the run of mine (ROM) pad will be blended into road haulage trucks and trucked the 8.5 kilometres to the process plant for direct tipping into the crusher.

Based on the Measured and Indicated Resources a mining, processing, production and mining cost schedule was developed based on the constraints of the process plant for production over a 23-year mine life. An upside production schedule was also developed, which included processing of Inferred Resources in the base case open pit. This extends the potential mine life by a further 12 years.

The Ore Reserves estimate for the Project is shown in Table 3.

Table 3
Nolans Project Ore Reserves
Announced 7 February 2019

Classification	Mt	TREO (%)	P_2O_5 (%)	NdPr Enrichment (%)
Proved	4.3	3.1	13	26.1
Probable	14.9	2.9	13	26.5
Total	**19.2**	**3.0**	**13**	**26.4**

Note: Numbers may not compute due to rounding.

Metallurgical Test Work

Substantial test work has been carried out on representative samples from the deposit which included:

- Extensive batch test work to develop the beneficiation and phosphoric acid pre-leach (PAPL) flowsheets.
- Optimising the flowsheet configuration and defining metallurgical and hydrometallurgical performance and operating parameters.
- Variability test work to develop the beneficiation geometallurgical model for the various geological material types and to understand the operating envelope for the hydrometallurgical processes.

Significant piloting has also been successfully undertaken to validate the flowsheet design and gather extensive operational and design information. The pilot program processed 15 tonnes of material from the Nolans deposit through the various unit of operations, including:

- Beneficiation.
- Phosphate extraction, which includes phosphoric acid pre-leach (PAPL), rare earth recovery, phosphoric acid regeneration and phosphoric acid purification to produce an MGA phosphoric acid product.
- Sulphation of the pre-leach residue followed by water leaching and rare earth precipitation.
- Rare earth processing, which includes the purification of the rare earths to remove impurities and produce a cerium hydroxide product and a rare earth chloride feed for separation.
- Rare earth separation to produce final rare earth products (completed as part of a previous pilot program and currently in preparation and planning for the current pilot program).

Processing

Ore from the ROM pad will be transported approximately 8.5 kilometres south to the process plant. The design for the DFS includes the following areas:

- Comminution and Beneficiation – ROM ore will be crushed, milled and beneficiated using flotation to produce a concentrate, which will be fed into the extraction plant, and tailings, which will be sent to the Residue Storage Facility (RSF).
- Extraction Plant – Hydrometallurgical processing area which will consist of all the unit operations that separate the rare earths from gangue minerals and produce an MGA phosphoric acid by-product, a cerium hydroxide product, and a rare earth chloride liquor which will be fed into the separation plant.
- Separation Plant – Solvent extraction facility and product handling area which will separate the final NdPr oxide product from the mid-heavy rare earth (SEG/HRE) carbonate product.
- Reagents – A general reagents handling and storage facility will be incorporated as well as a modular sulphuric acid plant (with one module installed during pre-production and the remaining two modules installed during the first two years of operation). A chlor-alkali plant to produce hydrochloric acid and sodium hydroxide will be installed during years six and seven of operation with bulk reagents imported to site prior.
- Services and Utilities –Includes raw water and other water services, power generation, steam generation, natural gas supply and distribution, and compressed air.

The beneficiation plant and associated equipment is designed to process a maximum of 1.0 Mtpa of ore. This is to cater for variation in ore grade over the life of mine.

The process plant is designed for 300,000 tpa of concentrate which relates to a nominal 13,343 tpa of TREO equivalent products with a potential maximum of 14,100 tpa depending on the mining schedule. Table 4 summarises the Project's product outputs.

Table 4
Products

Product	Average REO, P_2O_5* t	Average Product t
Cerium Hydroxide	8,383	10,271
NdPr Oxide	4,357	4,379
SEG/HRE Carbonate	603	1,064
Total Rare Earth Products	**13,343**	**15,714**
MGA Phosphoric Acid (54% P_2O_5)	73,336	135,808

* Average production is calculated as the arithmetic annual average following the anticipated three year ramp up period and excluding the partial final year of production.

Infrastructure

Infrastructure that will be developed as part of the Project includes:

- Sealed site access road from the Stuart Highway and unsealed mine access road from the process plant.
- Borefields for site water supply located 25 kilometres to the south and transfer system to the process plant.
- Gas-fired build-own-operate power station utilising gas from the adjacent Amadeus Gas Pipeline.
- Residue storage facility.
- Process plant and administration buildings.
- Permanent mine area infrastructure such as fuel supply, water supply, vehicle washdown and core shed with other mine area infrastructure provided by the mining contractor.
- Accommodation village with 300 permanent rooms and a further 350 leased rooms for construction.

Logistics

Desktop logistics studies determined the most efficient and economical supply chain for the Project. The Project will import the majority of reagents and consumables through Darwin Port or Port Adelaide.

The logistics for the Project will consist of:

- Unloading and loading of vessels in Darwin.
- Transport of goods to and from Darwin Port or the point of supply to intermodal facilities in Darwin and Adelaide.
- Five weekly rail services from both Darwin and Port Adelaide to Alice Springs.
- Unloading of rail at the Alice Springs intermodal terminal.
- Transport of containers from the Alice Springs terminal to site, unloading and return of empty containers to Alice Springs 24 hours per day, seven days per week.

Final products, containerised rare earth products and bulk MGA phosphoric acid, will be exported through Darwin Port. Bulk phosphoric acid will be stored in a dedicated tank with connection to the wharf for load-out.

Capital Cost Estimate

The capital costs for the Project have been developed consistent with the requirements of an AACE Class 3 estimate and is consistent with similar projects carried out in Australia.

A quantitative risk assessment and detailed Monte Carlo simulation was also completed with the mean contingency at 80% confidence calculated to be 12.6% and the accuracy assessed at -13.2% to +16.1%.

The capital cost estimate is expressed in Australian dollars (A$) although native currencies have been carried through to the financial model.

Table 5 summarises the capital cost estimate for the Project by area.

Table 5
Overall Project Capital Cost Estimate Summary by Area

Description	A$M
Mining Infrastructure	20.9
Pre-Production Mining	19.1
Beneficiation Plant	42.3
Extraction Plant	284.4
Separation Plant	48.1
Reagents & Services	147.9
Non-Process Infrastructure	173.2
Total Direct Cost	**736.0**
Temporary Construction Facilities	15.0
Travel & Accommodation	11.3
Detailed Engineering & PCM	64.9
Spares & First Fills	23.3
Mobile Fleet	5.6
Owner's Costs	36.7
Import duties	2.8
Total Indirect Cost	**159.6**
Contingency	110.4
Escalation	Excl.
Total	**1,006.1**

Note: Numbers may not compute due to rounding

Deferred capital has been estimated as follows:

- A$43.7 M for Modules 2 and 3 of the sulphuric acid plants, which will commence in year one of operations and be completed at the end of year two of operations.
- A$54.2 M for the chlor-alkali plant, which is anticipated to commence in year six and become operational at the beginning of year eight of operations.

Operating Costs

The operating cost estimate has been developed in line with a Class 3 estimate with a target accuracy of ±15%.

Operating costs have been estimated from first principles based on the Project design, metallurgical test work, supplier quotations, bulk reagent market research, operating experience and typical allowances.

Operating costs were estimated by cost type (labour, reagents, transport, consumables, energy, general and administration etc.) and then broken down into fixed and variable costs with the variable costs broken down by the following categories which were calculated as part of the production schedule:

- Tonnes of ore throughput.
- Tonnes of concentrate produced.
- Tonnes of sulphuric acid required.
- Tonnes of P_2O_5 in MGA phosphoric acid produced.
- Kilograms of TREO produced.

A summary of the nominal operating cost estimate by plant area is presented in Table 6.

Table 6
Nominal* Operating Cost Estimate Summary by Area

Area	**Without Chlor-Alkali**		**With Chlor-Alkali**	
	A$M per annum	**A$/kg TREO**	**A$M per annum**	**A$/kg TREO**
Mining**	42.6	3.19	42.6	3.19
Beneficiation	13.9	1.04	13.9	1.04
Extraction	124.5	9.32	107.2	8.03
Separation	25.7	1.93	20.1	1.50
General & Administration	21.0	1.57	21.1	1.58
Product Transport	26.7	2.00	26.7	2.00
Sub Total	254.3	19.05	231.5	17.34
Sustaining Capital	10.4	0.78	10.6	0.79
Total	264.7	19.82	242.1	18.13

* The operating cost model presented in the table is based on the nominal throughput, production rates and operating parameters determined from the SysCAD process model as opposed to the average production over the LOM.

** Mining operating costs are the average direct mining operating costs based on the base case mining schedule.

Financial Outcomes

The financial evaluation of the Project has been undertaken using a discounted cash flow (DCF) analysis in A$. The following basis has been used for the financial evaluation:

- Project design and construction period of 30 months followed by a 23-year operation period, based on processing Ore Reserves only, which includes a three-year ramp up period to full production.
- Capital costs as presented above with the inclusion of working capital and deferred capital for Modules 2 and 3 of the sulphuric acid plant and the chlor-alkali plant.
- Operating costs as presented above applied to the mining schedule with an allowance for additional labour, reagents, consumables and consultants during the ramp-up period.
- Sustaining capital distributed across the operating period with a loading towards later years and including A$20M across years one and two of production to achieve production ramp-up.
- US$/A$ exchange rate of 0.709 in 2019, 0.726 in 2020, reducing to 0.704 by 2023 and remaining constant thereafter.
- Discount rate of 10% with post-tax NPV calculated at the Project commitment date.
- Royalties as per Northern Territory legislation based on the higher of 2.5% of gross production revenue or 20% of net value.

Product pricing forecasts are based on an independent marketing report prepared by Roskill Consulting Group for rare earths and CRU International for phosphoric acid. Price forecasts are presented in Table 7.

Table 7
Base Case Price Forecast – Rare Earths US$/kg, P_2O_5 US$/t

	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030+
Cerium	1.24	1.21	1.25	1.29	1.26	1.30	1.22	1.20	1.18	1.21	1.23	1.26
NdPr	66.64	66.38	69.53	80.52	83.97	80.79	79.89	82.25	84.76	76.16	81.55	89.70
SEG/HRE	6.41	5.75	5.93	6.28	6.29	6.22	5.98	6.14	6.54	6.17	6.49	6.55
P_2O_5	612	623	630	637	641	648	659	673	683	683	683	683

An overview of the financial outcomes is presented in Table 8.

Table 8
Financial Outcomes

	US$ M per annum*	A$ M per annum*
Sales Revenue		
Rare Earth Products	379	539
Phosphoric Acid	35	50
Total Revenue (net of land transport, royalty & selling expenses)	**414**	**589**
Operating Expenditure		
Mining	30	43
Processing	103	148
General & Admin	15	21
Total Operating Expenditure	**148**	**212**
EBITDA	**266**	**377**

* Average production is calculated as the arithmetic annual average following the anticipated three year ramp up period and excluding the partial final year of production.

Based on these outcomes the Project has an average operating cost, net of phosphoric acid credit, of A$36.85 (US$25.94) per kilogram of NdPr oxide and generates an average EBITDA of A$377 M per annum. The Project has an after tax NPV_{10} of A$729 M (US$497 M) and an internal rate of return (IRR) of 17.43%.

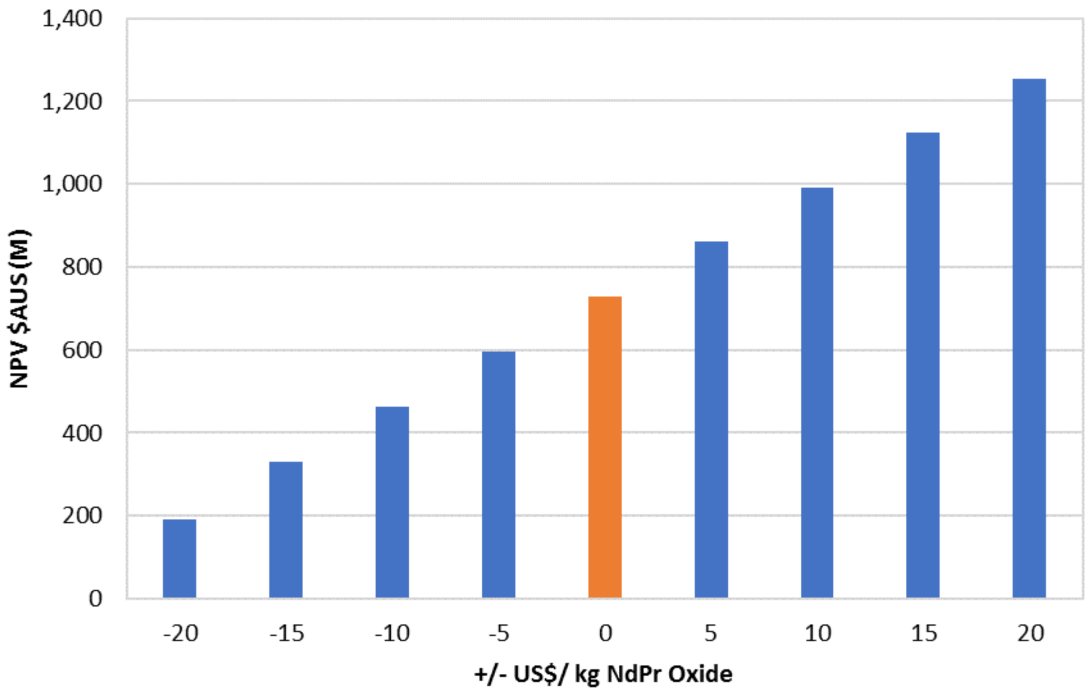
A number of additional scenarios and sensitivities have also been modelled as follows with the key financial outcomes presented in Table 9.

- A high NdPr oxide price scenario identified by Roskill, driven by higher electric vehicle demand, utilising an upside long-term forecast of US$149 per kilogram, as well as a less aggressive price forecast capped at US$115 per kilogram.
- The inclusion of Inferred Mineral Resources and non-preferred material types in the mining inventory which is likely to be processed and increases the mine life to 35 years. It cannot be assumed that Inferred Mineral Resources, due to geological uncertainty, and non-preferred material types, due to metallurgical uncertainty, will be upgraded to Ore Reserves and therefore there is no certainty that the analysis and outcomes for this scenario will be realised.

Table 9 Scenario Analysis				
Scenario	**Operating Cost US$/kg NdPr**	**NPV A$ million**	**IRR**	**Mine Life (Years)**
Base Case	25.94	729	17.43%	23
High NdPr Price Forecast	25.94	1,882	25.40%	23
Capped High NdPr Price Forecast	25.94	1,464	23.80%	23
Incl. Inferred/Non-Preferred Resources	24.48	903	17.91%	35

The Project is highly leveraged to changes in the NdPr oxide price. Analysis shows that for every US$5 per kilogram change in the NdPr oxide price, the Project EBITDA moves by approximately A$28 M and NPV_{10} moves by approximately A$130 M (Figure 3).

Figure 3
Project NPV_{10} A$ -NdPr Price Sensitivity



Project Implementation

The Project has environmental approval from both Northern Territory and Australian government regulators. The outstanding permitting requirements for the Project are the granting of the primary Mineral Lease (ML), an authority to mine and the water extraction licence. Grant of the ML requires the execution of a Native Title Agreement which is in the process of being negotiated with the Central Land Council (CLC). The Company anticipates that agreement will be reached in mid-2019 with the ML granted in the 3rd quarter of 2019.

Authority to commence mining on a granted ML is provided on approval by the regulator of the Project's mining management plan (MMP). This plan is in preparation and submission is anticipated to allow approval prior to, or in conjunction with, the granting of the ML.

The water extraction licence application has been submitted and is being considered by the regulator.

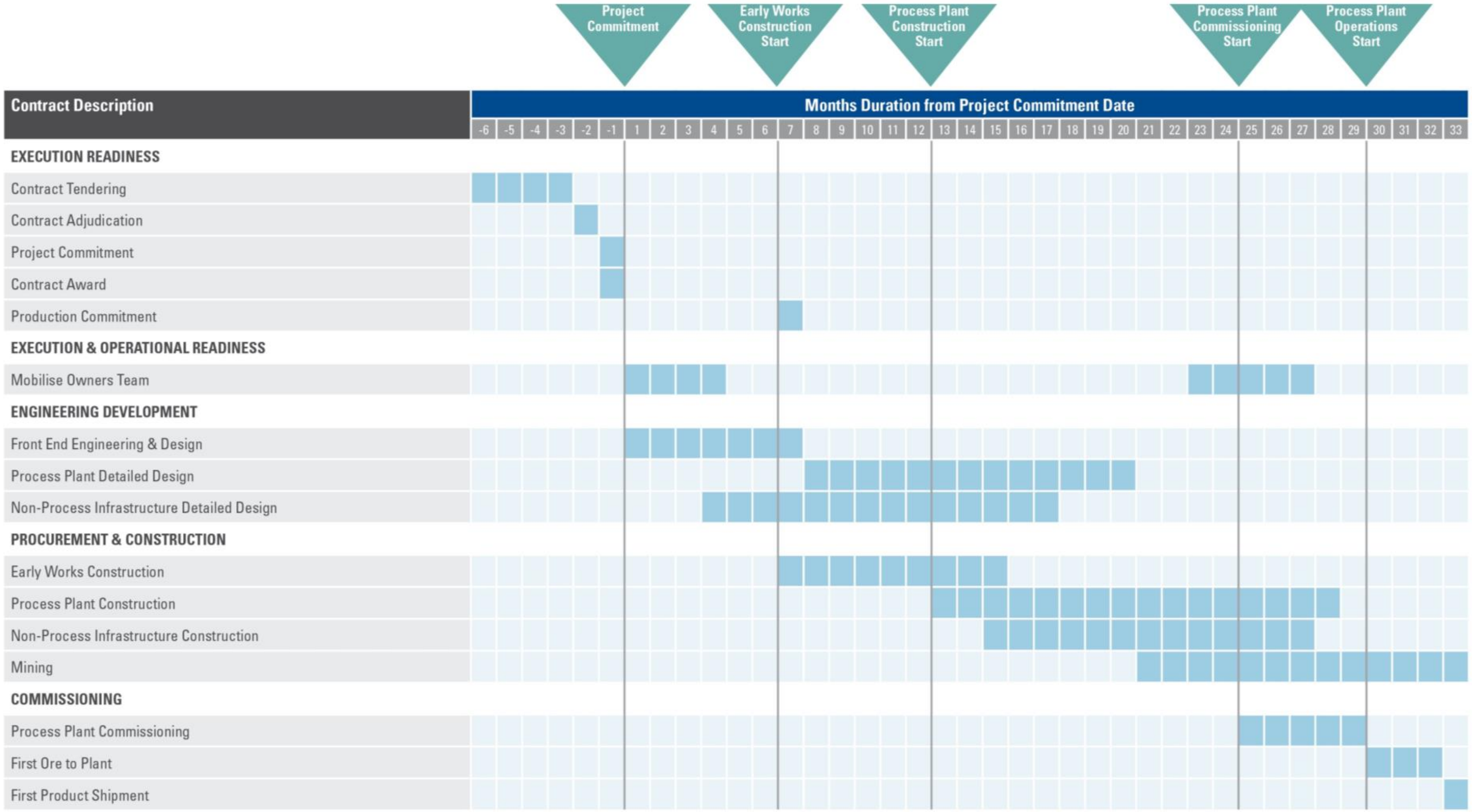
Following Project commitment, it is anticipated it will take 30 months for design and construction. Key durations include:

- Six-month front-end engineering and design (FEED) period.
- Six-month early works construction, following front-end engineering for access roads, water supply, accommodation village and bulk earthworks.
- 17-month process plant construction and pre-commissioning period following early works.
- 10-month RSF construction period to be ready two months prior to ore commissioning.
- 8-months pre-production mining following 3-months mining contractor mobilisation and site preparation.

Following completion of construction and pre-commissioning, ore commissioning and ramp-up will commence with an anticipated three-year period until nameplate production is reached. A development timeline is provided in Figure 4.

Figure 4

Development Timeline



1.2 Project Background

Arafura acquired title over the Project and surrounding tenements in May 2001, and in November 2003 announced the Project's maiden estimate of mineral resources: 3.8 million tonnes at 4.0% total rare earth oxide (TREO).

Between 2005 and 2015 Arafura completed significant metallurgical test work and pilot testing and a number of feasibility studies on various metallurgical flowsheets and Project configurations, however capital and operating costs, and resulting Project outcomes, remained unfavourable. In 2015-2016 Arafura undertook a detailed review of mineralised material types and mine planning scenarios, and a program of small-scale flotation and hydrometallurgical test work, which resulted in significantly improved Project economics. Based on this work Arafura adopted the phosphoric acid pre-leach (PAPL) extraction flowsheet, which had been in development and testing for a number of years by Arafura. The flowsheet also delivered the opportunity for the Project to produce MGA phosphoric acid of 54% P_2O_5.

Arafura submitted its draft Environmental Impact Statement (EIS), based on an earlier flowsheet and Project configuration, in mid-2016, and a supplement to the EIS, updating for the PAPL flowsheet, in early 2017, for which it secured Northern Territory and Australian government approvals in December 2017 and May 2018, respectively.

The PAPL flowsheet with all operations located at the Nolans site is the basis of this DFS.

1.3 Project Location

The Project is located in the southern part of the Northern Territory of Australia approximately 135 kilometres to the north of Alice Springs, as shown in Figure 1. The mineral resource that supports the development of the Project lies in a flat plain at the south-western end of the Reynolds Range, at latitude 22.58˚ south and longitude 133.24˚ east.

Nearly all the Project's development footprint is located on Aileron Station with the nearest areas of occupation being the Aileron Roadhouse and adjacent station homestead and the Alyuen Aboriginal family outstation approximately 15 kilometres from the site.

The proposed mine lies approximately 10 kilometres west of the all-weather, sealed transnational Stuart Highway which links the coastal cities of Darwin to the north, and Adelaide to the south. The mine also lies 65 kilometres west of the standard gauge Adelaide-Darwin railway.

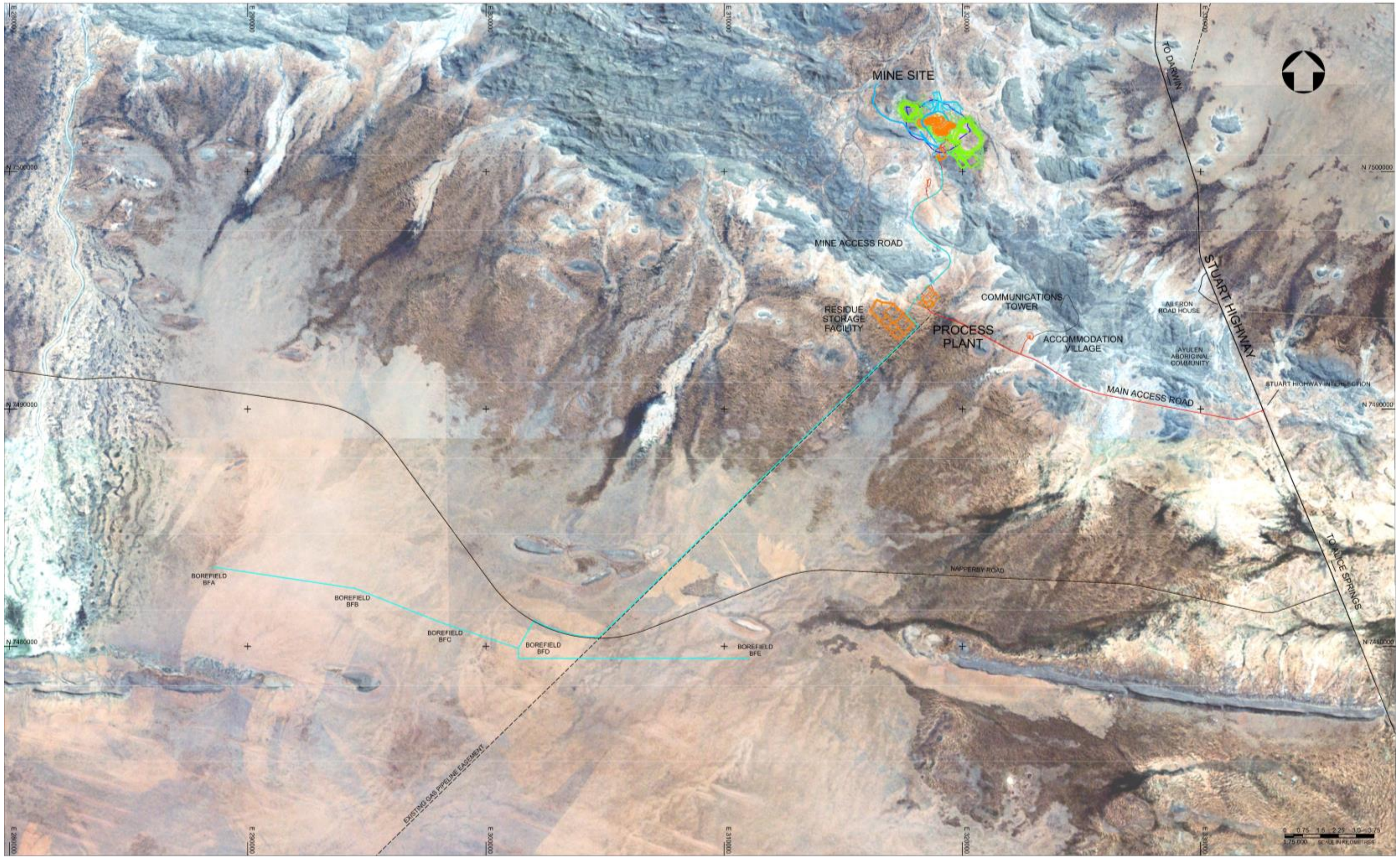
Both the highway and railway pass through the town of Alice Springs (population 28,700). Alice Springs is well served by modern road, rail, telecommunications and social infrastructure, and has daily flights to most Australian capital cities which eliminates the requirement for a dedicated airstrip and associated infrastructure at the Project site. Figure 1 shows the Project location and location of key infrastructure.

The Project site is not connected to a power grid however the Amadeus Gas Pipeline (AGP) passes within 250 metres of the Project's proposed process plant site.

Overall site layout is shown in Figure 5.

Figure 5

Overall Project Layout



The climate of the area is characterised by long hot summers and short mild winters. The average rainfall is approximately 280 millimetres, which falls predominately between October and March.

1.4 Ownership

Arafura Resources Limited (ACN 080 933 455) is an Australian Securities Exchange (ASX)-listed company with more than 7,400 shareholders. The Company's 2018 Annual Report lists J P Morgan Nominees Australia Limited as the largest shareholder (19.43% of issued capital), followed by ECE Nolans Investment Company Pty Ltd with 17.46%, whose parent entity is the Chinese state-owned enterprise East China Mineral Exploration and Development Bureau.

Five exploration licences (ELs) that underlie the full extent of the Project (ELs 28473, 28498, 29509, 31224 and 31284: total area 1,114.7 km^2), which includes the EL over the Nolans Bore mineral resource, have been granted to Arafura. Collectively these mineral titles provide Arafura with access for approved exploration activities and 100% of the mineral rights.

Applications for four mineral leases (MLs) (26659, 30702, 30703 and 30704) within which all major project development activities are planned, have been made by Arafura Rare Earths Pty Ltd (ACN 118 158 900), a wholly-owned subsidiary of Arafura.

To date, Arafura has had three patents granted, and filed an additional three patent applications, for metallurgical processes leading to the recovery of rare earths.

1.5 Definitive Feasibility Study Contributors

The work carried out as part of the DFS has built on previous studies commissioned by Arafura. A number of independent consultants have contributed to the study with responsibilities as outlined in Table 10.

Table 10
Study Contributors

Area	Contributor
Project Management & DFS Lead	Hatch Pty Ltd (Hatch), Arafura
Geology and Resource Evaluation	Arafura
Reserve Estimation	Mining Plus Pty Ltd (Mining Plus)
Mine Planning and Design	Mining Plus
Mine Geotechnical	AMC Consultants Pty Ltd (AMC)
Tailings Management & Geotechnical	Knight Piésold Consulting (Knight Piésold)
Metallurgical Processing & Process Design	Arafura, Hatch
Process Plant Design & Utilities	Hatch
Process Simulation	Arafura, Simulus Pty Ltd (Simulus)
Infrastructure	Hatch
Environment	GHD Pty Ltd (GHD), Arafura, JRHC Enterprises
Surface Water Hydrology	Knight Piésold
Groundwater Hydrogeology	GHD, Ride Consulting
Mine Closure Cost Estimates	Mining Plus, GHD
Human Resources	Strategic Human Resources Pty Ltd
Capital & Operating Cost	Hatch, Mining Plus, Knight Piésold, Arafura
Market Analysis – Rare Earths	Roskill Consulting Group Limited (Roskill)
Market Analysis – Phosphoric Acid	CRU International Pty Ltd (CRU)
Logistics Study	Qube Bulk Pty Ltd (Qube)

2 GEOLOGY

2.1 Regional and Deposit Geology

The Nolans Bore REE-P-U deposit occurs in the Aileron Province of the Arunta Region. The deposit is covered by a thin veneer of alluvium, colluvium and calcrete although scattered outcrops of fluorapatite (apatite) rich rare earth element (REE) mineralisation and the metamorphic host rocks occur either side of a 2 to 5-metre-deep North-South palaeochannel.

The geology of the southeast Reynolds Range area near Nolans Bore is characterised by widespread high-grade metamorphism during the 1595 Ma to1550 Ma (million years ago) Chewings Event. The 1860 Ma to1820 Ma Lander rock formation is the oldest geological unit in the area. Felsic orthogneisses form significant intrusive bodies throughout the region. Those at Nolans Bore are mapped as part of the 1806 Ma Boothby Orthogneiss although it is possible that some may be part of the nearby 1770 Ma Napperby Gneiss. Primary mineralisation at Nolans Bore cross-cuts these metamorphic rocks and is dated to between 1550 Ma and 1525 Ma which is the latest stages of the Chewings Event.

The Reynolds Range area is cross-cut by numerous steeply dipping shear zones that were active during the Ordovician-Carboniferous Alice Springs Orogeny. These shear zones have affected both the high-grade metamorphic host rocks and the mineralisation in various parts of the deposit.

The current landscape expression around the deposit mostly corresponds to a low-lying broad open valley in an area dominated by alluvial and colluvial sediments overlying variably weathered metamorphic basement rocks. Interpretations suggest the low-lying setting has persisted since at least the mid-Tertiary and this appears to be responsible for the variable and locally extensive development of weathering and oxidation at Nolans Bore.

2.2 Mineralisation

Lithology, mineralogy, colour, radiometrics and chemical composition are characteristic features of Nolans Bore-type mineralisation. These features and the typical sharp drop-off in grade and radioactivity easily distinguish mineralisation from the adjacent host rock units. Radiometrics is strongly correlated with TREO grade and a very reliable geophysical method to outline and define mineralisation. Overall the mineralisation is enriched in REE, P, U, Th, Ca, Sr and F and shows a distinct light REE enrichment, especially when compared to the host rocks.

The REE mineralisation at Nolans Bore is grouped into three major evolutionary stages which are broadly aligned with the geological events recognised in the region:

- Stage 1 – Primary mineralisation occurred towards the end of the Chewings Event.
- Stage 2 – Overprinting hypogene (process at depth) mineralisation (remobilised, brecciated and reworked) occurred during the Alice Springs Orogeny.
- Stage 3 – Supergene (process at or near surface) mineralisation and oxidation/weathering has occurred since the Mesozoic.

Primary (Stage 1) mineralisation occurs as moderately to steeply dipping veins of REE-rich apatite, up to tens of metres in width, with grades between approximately 5% to 10% TREO. Veins can be hundreds of metres long and typically dip north or northwest in the deposit's north zone although other orientations, including horizontal, occur elsewhere. Massive primary apatite veins consist of coarse apatite crystals within a microcrystalline apatite matrix. The veins contain trace to minor amounts of REE phosphates (monazite group minerals), silicates (*e.g*. allanite) and oxides (*e.g*. thorite). These often occur as abundant fine-grained mineral inclusions in apatite, or sometimes as separate minerals. The apatite itself contains REE, Th and U, and is the dominant REE-bearing mineral.

The apatite-rich veins typically show calcsilicate-rich margins with sharp to irregular contacts. Some veins and the associated calcsilicates contain trace to minor carbonate. Massive apatite-rich veins sometimes show evidence of brecciation. Detailed geochemistry typically shows an abrupt drop in grade at the vein margin with almost no dispersion of REE-P-U-Th-F into the adjacent host rocks.

The overprinting Stage 2 mineralisation is most prevalent in the central zone of the deposit where it is characterised by extensive allanite-veined apatite rubble breccias with amphibole plus allanite-epidote matrix infill. The breccia zones are extensive in places and span the range of breccia types. In places, this mineralisation is associated with broad zones of amphibole and/or epidote-rich calcsilicate alteration. In contrast to Stage 1 there is minor dispersion forming low grade REE halo in these altered calcsilicate zones.

TREO grades are typically lower in Stage 2 apatite-allanite breccias compared to the massive primary apatite mineralisation. Detailed petrology, electron microscope and QEMSCAN studies typically indicate that epidote and allanite are significant or major REE carriers in Stage 2 mineralisation.

Stage 3 mineralisation is variable in its distribution and intensity of development. The well-developed zones are localised to a few areas of the deposit. These are characterised by strongly oxidised apatite mineralisation with a very different P_2O_5/TREO ratio. Stage 3 mineralisation commonly has apatite, fine-grained monazite and crandallite group minerals. Hematite, goethite and limonite typically form along grain boundaries in apatite and in its mineral inclusions. They also occur together with chalcedony which partially infills voids after probable carbonate grains. Typically, extensive kaolin and clay alteration is developed in the host rocks around the intensely altered zones. In places, Stage 3 mineralisation approaches 50% TREO. The TREO spectra in Stage 3 is similar to Stage 1 although it can be slightly higher in light REE-enrichment. There is also localised minor dispersion of the REE forming low-grade haloes in the surrounding host rocks.

The depth to fresh rock is highly variable across the deposit. Weathering penetrates to depths of more than 200 metres down wider zones of brecciated and deformed mineralisation in the north and central zones. This strongly contrasts with adjacent or nearby host rocks and narrow veins of mineralisation which may only be weathered to a few metres below the current land surface. The preserved oxidation profile lacks an iron-rich cap and clearly indicates that at least part of the deposit has been removed by erosion.

The host rocks surrounding the mineralisation contain only trace sulphide minerals, with whole rock assays demonstrating trace sulphur and metal contents typical of average crustal rocks. Investigations into the waste rock geochemistry are currently underway to evaluate for the potential for acid mine drainage or neutral mine drainage with preliminary waste rock characterisation showing limited potential for acid mine drainage or neutral mine drainage.

2.3 Exploration

Outcropping apatite-rich REE mineralisation was first discovered by PNC Exploration (Australia) Pty Ltd in 1995 while following up two large spectrally distinct Th and U radiometric anomalies in their 1994 regional airborne survey. Grades of up to 10% TREO were reported in rock chip samples but the uranium content was considered too low to be of economic interest.

The deposit was identified as a potential hard-rock phosphate-REE target during a literature search in April 1999, with Arafura first visiting the prospect in May 1999. This was followed by an initial exploration program involving six costeans and nine shallow pits in January 2000. Arafura's emphasis quickly changed to rare earths as their economic potential became more apparent.

Between 2001-2018 a total of more than 100 kilometres of drilling has occurred in the Project area with almost 90 kilometres of this directed at the deposit itself. The geological understanding of the region is supported by airborne geophysical (including hyperspectral) surveys, reconnaissance mapping, prospecting and shallow exploration drilling at other REE targets. Several untested biogeochemical anomalies occur near the deposit and these are considered worthy of further exploration. Sterilisation drilling has occurred to the south-east of the deposit where mine infrastructure is planned. Test pits and geotechnical drilling also provide additional background information for other project infrastructure across the Project area. Arafura has used open file airborne electromagnetic datasets to target substantial drilling programs for regional groundwater investigation and monitoring activities in the southern basins area.

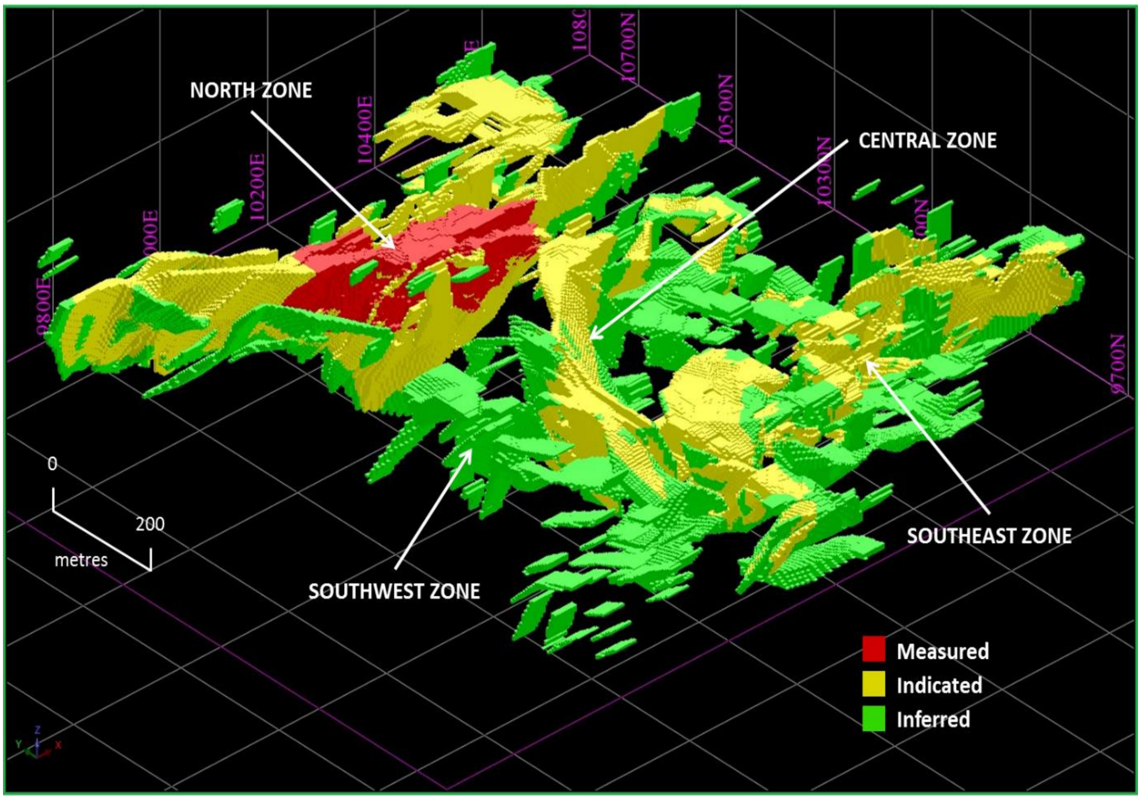
The Nolans Bore deposit has been systematically drilled to approximately 215 metres below the surface at a nominal 40 metre by 40 metre drill spacing, with localised 20 metre by 20 metre infill drilling in the north zone. The deposit is a complex three-dimensional geometry which is broadly subdivided into the north, central, south-east and south-west zones covering an area of about 1.4 kilometres by 1.5 kilometres as shown in Figure 6.

The north and central zones are the best geologically understood parts of the deposit with the most drill core from surface while the south-west zone is the least understood. Mineralisation remains open at depth across large parts of the deposit with the potential for additional resources considered highly likely. Deeper drilling in the north zone (two widely spaced holes) demonstrates that mineralisation extends below a vertical depth of 400 metres in this area. Nolans Bore is the only significant accumulation of REE mineralisation known in the Project area although other minor occurrences have been discovered within about 2 kilometres of the deposit.

The Nolans Bore geological model and Mineral Resources are based on data stored in Arafura's Geobank database. They comprise:

- Geological and survey data for 1,159 core and reverse circulation (RC) drill holes, and 9 costeans (99,315 metres).
- 29,012 routine assays, including 4,470 whole rocks assays, from 46,725 metres of the above drilling.
- More than 56 kilometres of downhole radiometric and survey data.
- 7,725 specific gravity measurements from drill core.
- 20,773 metres of downhole density probe data, of which 16,607 metre-average values from below the water table were accepted as usable data.
- Material type (MAT2016) classifications for 27,675 assay intervals.

Figure 6
Nolans Bore Deposit



Although minor mineralisation is present outside of the main deposit area, Mineral Resources have not been identified or modelled in 53 more distal exploration RC drill holes surrounding Nolans Bore. However, data from these drill holes have contributed to average compositions and densities for the host rocks on the peripheries of the model. Assay data from sterilisation drilling to the southeast of the deposit (421 shallow rotary air blast (RAB) holes and 10 vertical geotechnical core holes) were excluded from the resource model. Geological data from 48 wide-diameter holes at Nolans Bore was used to confirm the geometry of the geological model. Data from drilling at the nearby Mulga (REE) and Goanna (U) prospects are not included in the Nolans Bore database.

All drilling, surveys, logging and sampling was overseen by the Competent Person (Exploration Results or Mineral Resources) and/or experienced geological staff. The assayed intervals were selected based on detailed geological and radiometric logging, targeting mineralised intervals and their margins. Drill core was typically cut to geological boundaries, but RC samples were representative splits of metre-based samples. RC assay samples were often composited at the laboratory using equal weight methods. Routine assay samples were representatively sampled with systematic field duplicates and blanks collected and assayed to confirm sampling integrity. Assay mis-matches were investigated; the number of unresolved mis-matches is small indicating the geological sampling protocols and the database are reliable.

All samples have been assayed for 15 REEs plus phosphate, uranium and thorium using a modified ore-grade three-acid digest method suited to Nolans Bore-type mineralisation. In addition, aluminium, barium, iron and strontium were also routinely assayed by this method. Assay results have been confirmed via Certified Reference Material (CRM) and internal standards, duplicates and blanks, as well as systematic 1 in 20 interlaboratory check assays. Most referee assays utilised total or near total digest methods, CRM, internal standards, duplicates and blanks and strongly support the REE, P, U and Th results reported by the primary laboratory. This demonstrates that the assay results for the routine samples are acceptable. The results of all assays have been carefully assessed as part of a thorough QAQC procedure prior to loading into the database. Assay jobs whose standards failed QAQC protocols were redone. The whole rock results for SiO_2, TiO_2, Al_2O_3, Fe_2O_3, MgO, MnO, CaO, K_2O, BaO, SrO, SO_3, LOI and fluorine are a subset of the routine assay population because only total or near total digest methods have been accepted as delivering reliable data due to partial digest issues.

All collars have been surveyed by a professional surveyor. All downhole surveys were supported by the systematic use of a local calibration test hole at Nolans Bore to ensure consistency of measurements across all programmes. The surveyed downhole azimuths were adjusted for two separate survey periods in 2007/08 based on their observed deviations in the test hole and differences in holes resurveyed in 2011.

2.4 Mineral Resource

The geological model is based on wireframed sectional interpretations which identify and join an outer envelope encompassing all substantial intervals of mineralisation (MIN) with minimal dilution. Mineralisation is identified as intervals of 0.5% TREO or more. In most cases, this TREO grade clearly differentiates MIN from the typical host rocks assigned to WASTE.

The geological model was digitised and wireframed in SURPAC using standard sectional and extrapolation methods. Where possible the geology was extrapolated by the half-principal drilling distance (*i.e.* 20 metres) to ensure that all rock types and their volumes are equally represented in the geological model. The deeper drill intersections were extrapolated farther than this to smooth out zig-zag shapes across sections due to alternating drill depths. The central zone of the deposit was completely re-interpreted and manually wireframed in 2015 to remove unrealistic cog-like shapes introduced by the two different drilling directions and extrapolating between these sections. New wireframed DOMAINs were also produced for PEG (pegmatite) and SCH (schist) in 2015. A wireframe has not been produced for GNE (gneiss) as it is simply the remainder. Surfaces were also produced for the current land surface, base of complete oxidation, top of fresh rock and the standing water level. These wireframed DOMAINs and surfaces were used to domain the geological data for detailed analysis and modelling purposes, and to populate and flag attributes in the block model.

The parent block size of 20 metres by 20 metres by 5 metres in easting, northing and relative level (RL) (X, Y and Z) was chosen based on the principal drill section spacing and the typical drilling density and are considered optimal for a deposit wide estimate. The empty volume block model was aligned to the local grid with its extents covering the existing topography, depth of mineralisation and the perceived limits of an open pit.

The wireframes for 138 mineralised DOMAINs were grouped into geospatial areas based on location, geology, geochemistry and oxidation state. A total of eight mineralised ZONECODEs were created and the drill hole data and volume model flagged for DOMAIN, ZONECODE and oxidation state. The data was analysed and evaluated to determine suitable independent estimation, search and variogram parameters for each ZONECODE. The estimation of grade was completed sequentially for each mineralised ZONECODE with TREO, P_2O_5, U_3O_8, ThO_2, La_2O_3, CeO_2, Pr_6O_{11}, Nd_2O_3, Eu_2O_3, Gd_2O_3, Tb_4O_7, Dy_2O_3, Ho_2O_3, Er_2O_3, Tm_2O_3, Yb_2O_3, Lu_2O_3 and Y_2O_3 estimated first. The major whole rock oxides (*i.e.* SiO_2, TiO_2, Al_2O_3, Fe_2O_3, MgO, MnO, CaO, K2O, BaO, SrO, SO_3 and LOI) and fluorine were then subsequently estimated into each ZONECODE in a second and third estimation phase. Most of the major oxides were estimated in 2017 although some were done in 2018 along with the estimation of all material types.

Variograms were modelled for TREO, P_2O_5, U_3O_8 and ThO_2 to resolve the dataset continuity in each mineralised ZONECODE. Detailed statistical analysis shows the individual rare earths, TREO, P_2O_5, U_3O_8 and ThO_2 are all strongly correlated. The modelled variograms and their parameters are also similar for each ZONECODE. Consequently, the selected continuity directions and search parameters are based on the TREO model alone. The continuity directions are mostly down-dip consistent the geological model and geological structures. However, ZONECODE14 in the north zone has a sub-horizontal continuity direction. It is argued that this search direction is appropriate for this ZONECODE; and despite being at a high angle to the wireframed mineralisation, it is consistent with expected trends for strongly oxidised near surface mineralisation.

The grades for the mineralised ZONECODEs were estimated using ordinary kriging (OK) for TREO, P_2O_5, U_3O_8, ThO_2, La_2O_3, CeO_2, Pr_6O_{11}, Nd_2O_3, Eu_2O_3, Gd_2O_3, Tb_4O_7, Dy_2O_3, Ho_2O_3, Er_2O_3, Tm_2O_3, Yb_2O_3, Lu_2O_3 and Y_2O_3. TREO, P_2O_5, U_3O_8 and ThO_2 were estimated into WASTE using inverse distance squared (ID2) methods. The major oxides were estimated into all DOMAINs using ID2 methods. The fluorine grade is based on correlation with the phosphate grade in the mineralisation and by assignment in waste. Each estimate used a standard three pass approach, where model cells without a grade estimate in the first pass went through a second and, where necessary, a third pass. Most mineralised ZONECODEs were largely filled in the first two passes. Due to a highly variable oxidation surface and distal data, one ZONECODE required an expanded fourth pass to estimate a small number of cells. Domain averages were used for the more distal parts in WASTE.

The searches were anisotropic in the mineralised domains and the search ellipse dimensions were expanded by factors of 2.5 and 4 respectively for each successive pass. The minimum and maximum number of samples was set to 10 and 30 respectively for the first two passes but the minimum varied from 2 to 10 in the third pass. WASTE was estimated using a series of expanding isotropic searches for each geological unit and oxidation state. Waste blocks that were not filled in the third pass were directly assigned average values for the relevant geological unit and oxidation state.

Cell discretisation was set to 5, 5, and 3 in X, Y and Z, respectively. Where grades were kriged, negative kriging weights were allowed, and a maximum of six composited samples were allowed from any one hole. Short-length composite intervals were used in this estimate, but they were length-weighted to ensure an unbiased contribution to the result.

Density was informed by a combination of systematic drill core specific gravity (SG) measurements and an extensive downhole probe dataset. The datasets were assessed, combined and split into domains based on geological wireframes and oxidation boundaries. Density was estimated into the model using a combination of ID2 with expanding search radii and direct assignment based on average values where data was limited.

The activity of the mineralised domains was calculated from the estimated U_3O_8 and ThO_2 grades whereas the activity of WASTE was estimated using values derived from calibrated downhole gamma surveys.

The fraction of each material type was estimated into the model based on nearest neighbour methods. The material types were classified according to their assay interval and composited into 5 metre intervals for this estimate.

The Mineral Resources have been classified based on multiple inputs and the constraints used to inform the grade estimate in the block. The following factors were considered in the resource classification of each block and include:

- Continuity and confidence in the geological interpretation.
- Number of the OK estimation pass used to fill the block.
- Drill hole spacing.
- Number of informing samples.
- Average distance used to inform the OK estimate of grade.
- Variography and kriging constraints.

Preliminary boundary strings were digitised on a section by section basis for Measured and Indicated categories. These were then adjusted and rationalised by using a series of different passes considering the above factors. The final strings were then wireframed to form a classification shell and used to assign a preliminary resource classification for each block. The preliminary assignment was then reviewed on a section by section basis with numerous blocks near the edge of the wireframed shells manually reclassified to ensure geological continuity and a coherent nature to the final resource classification.

The Identified Mineral Resources, as announced on 7 June 2017, at Nolans Bore are classified according to the 2012 JORC Code guidelines and shown in Table 11. The model has been verified by sectional views of the model, wireframe and drill hole data, and by statistical evaluation. There have been no material changes to the informing data in Arafura's database since the mineral resource was announced. The current resource model has only been updated to provide more detailed breakdown of the individual material types and some additional major oxides with the resource classification, grades, tonnages and all other relevant model attributes remaining the same as those used in the development of the Mineral Resource estimate.

Table 11
Statement of Mineral Resources for the Nolans Bore Rare Earth Deposit
Announced 7 June 2017 – 1% TREO lower cut-off grade

Category	Tonnes (Mt)	TREO (%)	P_2O_5 (%)	NdPr Enrichment (%)
Measured	4.9	3.2	13	26.1
Indicated	30	2.7	12	26.4
Inferred	21	2.3	10	26.5
Total	**56**	**2.6**	**11**	**26.4**

Note: Numbers may not compute due to rounding. "NdPr Enrichment" is the proportion of TREO comprising neodymium oxide Nd_2O_3 and praseodymium oxide Pr_6O_{11}.

The stated TREO grade is based on the sum of the estimated grades for La_2O_3, CeO_2, Pr_6O_{11}, Nd_2O_3, Sm_2O_3, Eu_2O_3, Gd_2O_3, Tb_4O_7, Dy_2O_3, Ho_2O_3, Er_2O_3, Tm_2O_3, Yb_2O_3, Lu_2O_3 and Y_2O_3.

The proportion of each rare earth oxide is presented in Table 12.

Table 12 Percentage Proportion of TREO in the Mineral Resources				
	Measured	**Indicated**	**Inferred**	**Total**
La_2O_3	19.5	19.3	19.2	19.3
CeO_2	48.7	48.7	48.7	48.7
Pr_6O_{11}	5.9	5.9	5.9	5.9
Nd_2O_3	20.2	20.5	20.6	20.5
Sm_2O_3	2.3	2.3	2.3	2.3
Eu_2O_3	0.4	0.4	0.4	0.4
Gd_2O_3	0.9	1.0	1.0	1.0
Tb_4O_7	0.07	0.08	0.09	0.08
Dy_2O_3	0.3	0.3	0.3	0.3
Ho_2O_3	0.05	0.4	0.04	0.04
Er_2O_3	0.08	0.09	0.09	0.09
Tm_2O_3	0.01	0.01	0.01	0.01
Yb_2O_3	0.06	0.05	0.05	0.05
Lu_2O_3	0.007	0.007	0.007	0.007
Y_2O_3	1.5	1.3	1.3	1.4

Note: numbers may not compute due to rounding.

Grade-tonnage curves for TREO and P_2O_5 in the total resource are presented in Figure 7 and Figure 8.

The quality of the major oxides estimate can be assessed by summing all estimated values. Values between 95% and 105% are considered good, whilst totals of less than 90% or greater than 110% indicate a poor estimate and should be considered informative only. The major oxides estimate has a best confidence level equivalent to the Inferred Resources category, with the quality of the estimate ranging from good to poor and dependent on the proximity of informing samples. This occurs since the informing assay samples are a subset that largely targeted representative material within a proposed year 10 pit shell based on mining studies completed in 2012. Approximately 96% of the estimated major oxides are considered good to moderate within this proposed pit shell. Due to differences in estimation methods and data density, the whole rock composition of a block can be at odds with the material type. There are also instances where the density is at odds with the material type but overall the model differences average out.

Figure 7
TREO Grade-Tonnage Curve

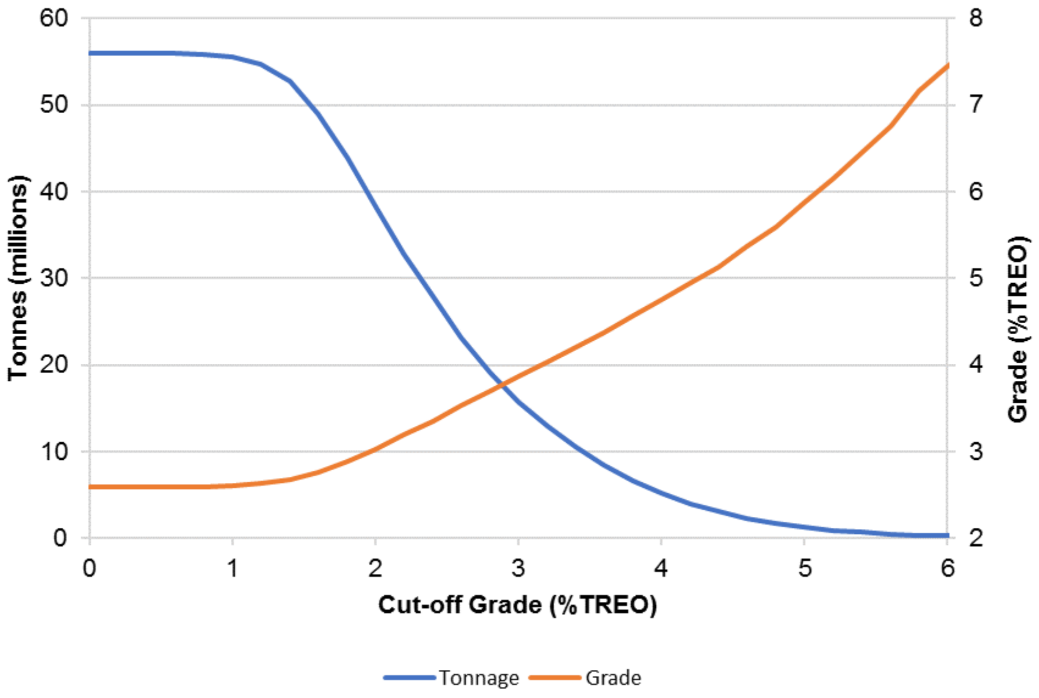
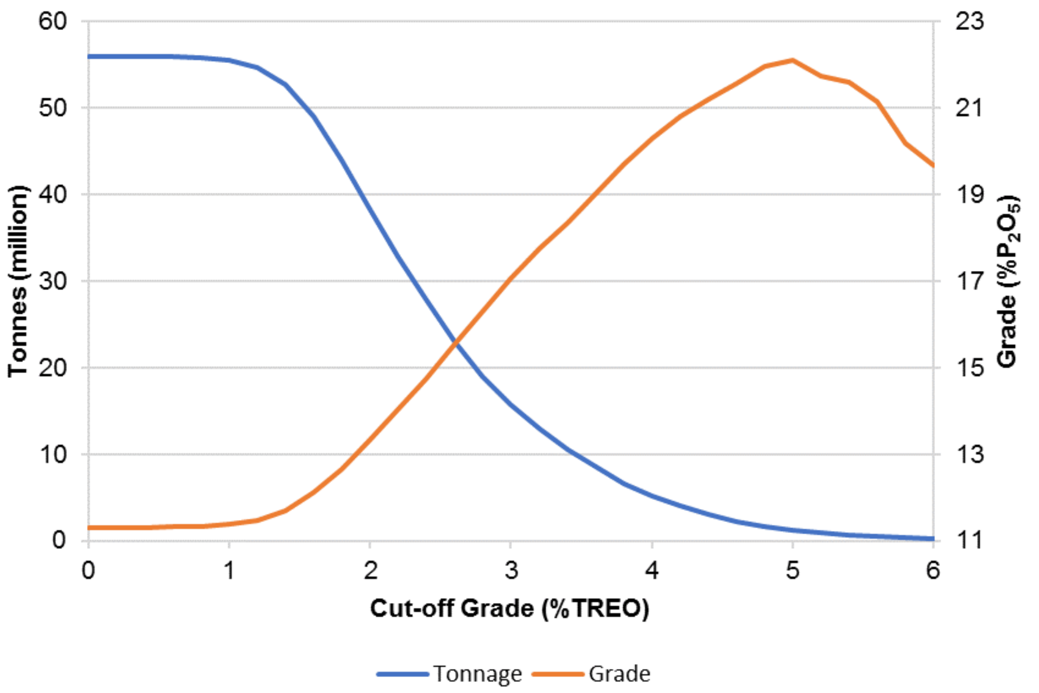


Figure 8
P_2O_5 Grade-Tonnage Curve



2.5 Geometallurgical Classification

The MAT2016 material type classification scheme reflects geological and mineral associations and targets the dominant REE minerals in the deposit. Initially designed around the perceived recovery of REEs in the PAPL flowsheet and the flotation of phosphate minerals, the scheme is largely based on differentiating phosphate-dominated mineralisation from calcsilicate-rich phosphate mineralisation.

Apatite contains REEs and, in addition, typically contains minute REE mineral inclusions (*e.g.* monazite group minerals, allanite, thorite, *etc*.). Hence by association, most of the REEs should be recovered providing the grind size does not liberate these inclusions and the apatite material floats. The identification of the dominant calcsilicate minerals is also important to the geometallurgical model because epidote group minerals can host significant REEs. Epidote group minerals (*i.e*. epidote and allanite) show a spectrum of REE compositions, ranging from close to zero in end-member epidote to approximately 25% TREO in end-member allanite, with all compositions in between present at Nolans Bore. As calcsilicate minerals are unlikely to float in the proposed flowsheet, significant epidote and allanite will lead to lower REE recoveries in flotation. Hence, an appreciation of whether these occur as a trace, minor or significant minerals is important to the overall material type classification and the geometallurgical model.

An important additional consideration in the scheme's design is that some elements are deleterious to downstream REE recoveries in the PAPL hydrometallurgical process (*e.g.* Al, Fe and Mg). Consequently, the classification must also consider the clay-rich and the more intensely oxidised material types where fine Fe oxides, clays and/or crandallite group minerals may float along with apatite with which they have a close association. Fortunately, the Al, Fe and Mg in the calcsilicates is not an issue as these minerals are unlikely to float.

Thus, it is important to identify:

- Phosphate-dominant mineralisation from calcsilicate-rich phosphate mineralisation.
- Amount and types of calcsilicate minerals.
- Oxidised or fresh apatite.
- Amount of clay minerals.

The individual MAT2016 material types have been grouped into:

- PAPL preferred material types (PAPLP).
- Non-preferred material types with abundant Fe oxides, clays and crandallite group minerals (NP1).
- Non-preferred material types with significant allanite and/or epidote (NP2).
- WASTE.

Material types are assigned to PAPLP where apatite and/or its associated mineral inclusions host most of the REEs. It was anticipated from previous QEMSCAN studies that the mineral inclusion rich apatite would float and high REE and P recoveries in the metallurgical test work indicate this is the case. The PAPLP group also includes calcsilicates, but only when epidote and allanite are trace to minor components. NP1 is identified as a special case where deleterious elements may lead to potential downstream REE recovery issues due to the intimate association of Fe oxides, crandallite group minerals and apatite. NP2 is assigned to material types with significant epidote and/or allanite, as the REEs in these minerals are unlikely to be recovered in flotation. It is likely that all material types can be processed; however, recoveries are reduced in the non-preferred types.

Meaningful compositional and tonnage statistics for the individual material types cannot be extracted from a proportional block model because numerous blocks have combinations of different material types. This occurs because the geological relationships are complex and the individual material types typically have variable and different grades and densities. Consequently, the database was interrogated to determine the average grades of each material type and indicative volume proportions in the block model shown in Table 13.

A comprehensive variability test work program was undertaken to define the metallurgical recovery parameters and process performance for the various material types (refer Sections 3.2 and 4.2 of this report).

Representative material types were tested for metallurgical performance and used for development of the geometallurgical model. PAPLP types were prioritised and included in the pilot study. Test work samples were selected by the Competent Person from both Measured and Indicated Resources and focussed on testing a range of material types and compositions in the initial mining period. The test work samples were sourced from drill core and bulk samples collected from the wide diameter drilling campaign.

Table 13
Indicative Average Grades and Quantities for the Individual Material Types

MAT2016 Type/Group	Description	Average TREO (%)	Average P_2O_5 (%)	NdPr Enrichment (%)	Volume % Measured & Indicated Resources
0A - Waste	Country rock with no evidence of MIN.	0.11	0.15	21.2	3
0B1 - Waste	Country rock with evidence of minor MIN but <0.5% TREO.	0.21	0.66	23.6	7
0B2 - Waste	Country rock with evidence for minor MIN but >0.5% TREO.	0.69	2.6	24.9	2
0B3 - Waste	Country rock but geochemical evidence for MIN. No obvious MIN in RC chips.	1.6	6.6	25.9	<1
0C - Waste	Altered country rock with <0.5% TREO.	0.20	0.68	23.8	3
1 - PAPLP	Cream/green apatite with <2% allanite (<30% clay and <25% calcsilicate).	6.1	28	27.0	7
2 - PAPLP	Brown apatite with <2% allanite (<30% clay and <25% calcsilicate).	6.4	29	26.6	7
3A - NP1	Fine grained monazite and crandallite-rich MIN >30% clay	9.2	9.5	25.9	1
3B - PAPLP	TREO >0.5% and >30% clay with oxidised apatite, cheralite, kaolin and clay	2.7	12	25.9	27
3C - Waste	TREO <0.5% and >30% clay with mixture of oxidised country rock, apatite, cheralite, kaolin and clay	0.20	0.77	22.6	3
4A - PAPLP	Apatite with 2-10% allanite	5.5	26	27.1	2
4B - NP2	Apatite with >10% allanite	5.0	24	26.8	1
5A1 - PAPLP	>25% OH-free calcsilicates + apatite + <10% allanite	2.3	9.9	26.5	20
5A2 - NP2	>25% OH-bearing calcsilicates + apatite + <10% allanite	1.9	8.2	26.2	14
5B2 - NP2	>25% OH-bearing calc-silicates + apatite + >10% allanite	3.2	13	25.9	1
6B - NP2	>30% clay, >25% calcsilicates + apatite + allanite; TREO > 0.5%	2.1	8.9	25.0	<1
6C - Waste	>30% clay, >25% calcsilicates + apatite + allanite; TREO < 0.5%	0.25	1.5	23.0	<1

Note: Numbers may not compute due to rounding.

2.6 Grade Control

Grade control for the Project will consist of numerous processes to support the various ranges of mine plans. The processes that will be implemented onsite include but are not limited to:

- Geological grade control consisting of infill RC drilling programs and updated resource modelling.
- In-pit geological mapping.
- Production blast hole sampling and analysis.
- Grade control block model development to facilitate the development of detailed ore block-outs and dig plans.
- Selective blasting, and mining methods utilising:
  - High precision GPS.
  - Production management systems.
- Dump truck gamma discriminator units.

2.6.1 Geological Grade Control

Geological grade control has been designed with infill drilling based on the geology of the deposit and the block model. The proposed geological grade control drilling is planned as a series of staged programs that specifically target the Measured and Indicated Resources within the identified pit stages as outlined by the mining schedule. It is expected that the proposed level of geological detail and new data should provide the necessary information to better inform and update the block model in geology, material type and grade to facilitate annual mine planning, prior to blast hole drilling.

Geological grade control primarily utilise RC drilling together with geological logging, downhole gamma logging, sampling, assays and material type classification methods and procedures identical to those used to define the block model. Downhole optical scanning and the use of larger RC chip samples should resolve the potential geological concerns around the possible mis-classification of important material types in RC drilling. Along with the RC drilling and associated investigations a small number of diamond core drilling holes may be included to increase confidence in geological logging of material types.

Drilling programs have been specifically designed for geological grade control in pit Stages 1, 2 and 3. These programs are relatively small and will be completed within a short time frame ahead of each pit stage. The remainder of the planned drilling has been assigned to the final pit (pit Stage 7) and will be spread across six years.

The design is based on inclined drilling with an average 20 metre spacing on the principal drill sections and a 40 metre-spaced pattern on the alternate sections. This level of infill drilling is adequate for geological grade control as it will provide a better understanding grade and material type variability across the deposit.

3 MINING

3.1 Mineral Resource

The Mineral Resources that form the basis of the Ore Reserves were estimated in 2017 by Arafura, announced on 7 June 2017, and are reported in accordance with the JORC Code (2012 Edition).

Arafura developed the material classification regime which was included into the Mineral Resources and then used as the basis for the development of the geometallurgical model underpinning the estimation of metallurgical performance.

3.2 Pit Optimisation

3.2.1 Optimisation Parameters

Metallurgical Recoveries

Resource modelling included the estimation of 13 material types with varying mineralisation properties, of which five were to be included as potential ore sources. For these five material types methodology and equations were developed based on the metallurgical test work to estimate the production through the various processing streams to generate the final products.

The geometallurgical equations are based around the material behaviours for each of the preferred ore types through the flotation and PAPL circuits. As such, the recoveries focus on the P_2O_5, Fe_2O_3, Al_2O_3 and MgO feed grades and individual recoveries to calculate the concentrate production rates and grades, and are grouped into three ore types which can be summarised as:

- Ore Type 1 – Material Type 1 and 2.
- Ore Type 2 – Material Type 3B.
- Ore Type 3 – Material Type 4A and 5A1.

The phosphoric acid impurity implication ratio (PAII), which represents the build-up of impurities in the PAPL circuit, is calculated using the expected concentrate compositions and has been defined as:

$$1.8944 \times \frac{MgO}{P2O5} + 1.4617 \times \frac{Fe2O3}{P2O5} + 1.1732 \times \frac{Al2O3}{P2O5}$$

When this ratio exceeds 2.0, or if the block proportion of material type 3A is greater than 5% the whole block is rejected.

The 13 material types are proportionally coded into the resource model such that any number of these material types could be present in any one resource block. Each of the three ore types has different concentrate recovery equations.

To accommodate the material type proportions and multiple recoveries, the concentrate compositions, final product tonnages and elemental revenues were calculated for each ore type within each block. This totalled revenue was then utilised in the optimisations to determine if the block should be mined or not.

The key concentrate composition equations have been defined below in Table 14.

Table 14
Key Concentrate Composition Equations by Material Type

Parameter	Type 1 & 2	Type 3B	Type 4A & 5A1
Mass Recovery	N/A	N/A	$19.32 \times (Fe_2O_3/P_2O_5)^{-0.518}$
P_2O_5 Recovery	99%	$0.63 \times P_2O_5 + 87.24$ (max 99%)	N/A
P_2O_5 Grade	$0.9651 \times P_2O_5 + 1.6389$ (min 27%)	$0.2162 \times P_2O_5 + 27.276$	$0.5186 \times P_2O_5 + 20.214$ (max 28%)
TREO Recovery	$0.29 \times TREO + 95.96$	$71.27 \times (TREO)^{0.2382}$ (max 97.5%)	$170.97 \times [0.0815 \times (Fe_2O_3/P_2O_5)^{-0.786}]^{0.5937}$ (max 97%)
Fe_2O_3 Recovery	$11.6 \times (Fe_2O_3/P_2O_5)^{-0.559}$		
Al_2O_3 Recovery	$5.92 \times e^{(0.343 \times \text{Fe2O3 Recovery})}$		
MgO Recovery	$7.69 \times e^{(0.297 \times \text{Fe2O3 Recovery})}$		
H_2SO_4 Consumption	828.7 kg/t concentrate		

In addition, the metallurgical recovery of the REEs from the concentrate to final products is defined for each rare earth oxide with the recoveries given in Table 15.

Geotechnical Parameters

Geotechnical investigations have been completed by AMC Consulting (AMC) in 2012 around previous feasibility studies. These studies recommended a number of pit slope configurations for various sectors around the existing pit designs. These recommendations have been reviewed by AMC and remain valid for the current studies and have been utilised as the basis of the optimisation and pit design slope configurations.

Mining Costs

The mining costs were built up from both contractor market pricing submissions and a mining cost first principles estimate. These were compared, and a most likely estimate prepared which was broken into five main areas:

- Fixed costs.
- Clearing and topsoil stripping.
- Drill and blast.
- Load and haul.
- Ore haulage to the process plant.

Table 15 TREO Recovery Parameters		
		Recovery of Oxide in Concentrate
La_2O_3 Recovery	t	0.9240 x La_2O_3
CeO_2 Recovery	t	0.9460 x CeO_2
Nd_2O_3 Recovery	t	0.9052 x Nd_2O_3
Pr_6O_{11} Recovery	t	0.9115 x Pr_6O_{11}
Sm_2O_3 Recovery	t	0.8064 x Sm_2O_3
Eu_2O_3 Recovery	t	0.8064 x Eu_2O_3
Gd_2O_3 Recovery	t	0.8064 x Gd_2O_3
Dy_2O_3 Recovery	t	0.1922 x Dy_2O_3
Tb_4O_7 Recovery	t	0.1922 x Tb_4O_7
Er_2O_3 Recovery	t	0.1922 x Er_2O_3
Ho_2O_3 Recovery	t	0.1922 x Ho_2O_3
Lu_2O_3 Recovery	t	0.1922 x Lu_2O_3
Tm_2O_3 Recovery	t	0.1922 x Tm_2O_3
Yb_2O_3 Recovery	t	0.1922 x Tb_2O_3
Y_2O_3 Recovery	t	0.1922 x Y_2O_3

* La_2O_3 recovery to final product is only applicable if the lanthanum recovery circuit is included in the separation plant, where this circuit is excluded then there is no La_2O_3 recovery (as is the case for the base case of the Project)

The load and haul costs were estimated from the individual bench rates for ore and waste and then applied as a best fit regression line for the seven pit areas and the three oxidation states. Ore costs were applied only to blocks which contained the three ore types described above.

Drilling and blasting costs were also estimated from the contractor submissions for the three oxidation types. Table 16 summarises the mining cost parameters.

Non-Mining Operating Costs

Non-mining operating costs for use in the optimisation were provided as a series of fixed and variable costs for the various parts of the processing. The costs were built up from previous studies and preliminary DFS project cost estimates derived from ongoing definition of the Project's parameters. These are summarised in Table 17.

The fixed annual charge includes all non-mining labour, power generation, plant maintenance, operation of the laboratory, general and administration costs, and a portion of the consumables and logistics costs.

Table 16 Mining Cost Parameters		
Fixed Costs		
Annual Charge	\$/bcm	3.55
Variable Cost		
Clearing & Stripping	\$/bcm (oxide)	0.90
Road Haulage	\$/bcm (ore)	4.71
Load and Haul		
Oxide Waste	Regression	Rate = -0.0103 x RL +10.386
Oxide Ore	Regression	Rate = -0.0103 x RL +10.394
Transitional Waste	Regression	Rate = -0.0103 x RL +10.972
Transitional Ore	Regression	Rate = -0.0103 x RL +10.980
Fresh Waste	Regression	Rate = -0.0103 x RL +12.162
Fresh Ore	Regression	Rate = -0.0103 x RL +12.170
Drill and Blast		
Oxide	\$/bcm	0.914
Transitional	\$/bcm	1.512
Fresh	\$/bcm	2.230

Table 17 Non-Mining Cost Parameters		
Fixed Costs		
Annual Charge	A\$/a	98,638,569
Variable Cost		
Milling	A\$/t ore	9.12
Concentration	A\$/t con	13.86
Acid Consumption	A\$/t H_2SO_4	105.75
P_2O_5 Production	A\$/t P_2O_5 product	288.89
TREO Production	A\$/t TREO product	5.30

Revenues

Rare earth pricing was supplied from the draft Roskill marketing report dated September 2018. Phosphoric acid pricing was from current pricing at September 2018 with an independent report under preparation at the time. All pricing was FOB in Darwin.

Key prices used in the optimisation were:

- US$89.50/kg for Nd_2O_3 and Pr_6O_{11}.
- US$2.30/kg for CeO_2 (with 50% payability for cerium carbonate).
- US$12.40/kg for middle rare earths (with 35% payability as an unseparated oxide).
- US$73.30/kg for heavy rare earths (with 35% payability as an unseparated oxide).
- US$730/t of contained P_2O_5 for MGA phosphoric acid.

A fixed US dollar exchange rate of $0.712 was used for the pit optimisations.

3.2.2 Optimisation Results

Pit optimisations were completed for:

- Measured Resources only, to target the highest confidence ore zones.
- Measure and Indicated Resources, to determine the final pit limits and subsequent Ore Reserves.
- Measured, Indicated and Inferred Resources, to determine the upside potential of the Project and to provide a limit for locating infrastructure.

The discounted cash flow (DCF) for each of the above optimisation runs is calculated based on a nominal mill throughput of 800,000 tpa and a discount rate of 10%.

Within the final selected shell, based on the optimum outcome for the specified case, five smaller shells were selected for pit stages. These were:

- Measured only shell 16. Selected as it focusses on the majority of the Measured Resources and contained sufficient ore to provide a significant proportion of the revenue in the payback period.
- Measured and Indicated shell 9. This aligns well with the Measured only shell and provides the outlines for the two southern pits.
- Measured and Indicated shell 11. This shell connects the two southern pits.
- Measured and Indicated shell 15, which outlines the north west pit.
- Measured and Indicated shell 20, the final pit, which produces the highest discounted cash flow for the above parameters.

A summary of the shell-by-shell reports is shown graphically in Figure 9.

Figure 9
Measured and Indicated Optimisation Results

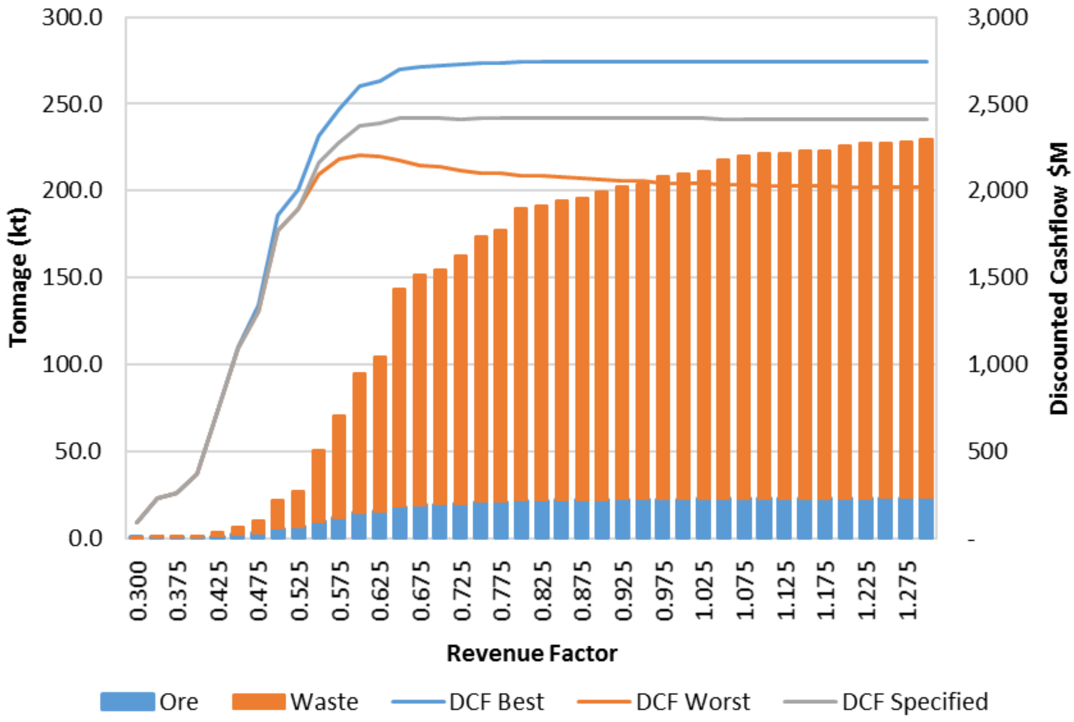


Figure 10 shows the selected shells in relation to each other and indicates the individual, discrete pit areas that would be mined first. Figure 11 shows the selected final shell contoured on 5 metre intervals.

Figure 10
Optimisation Shells

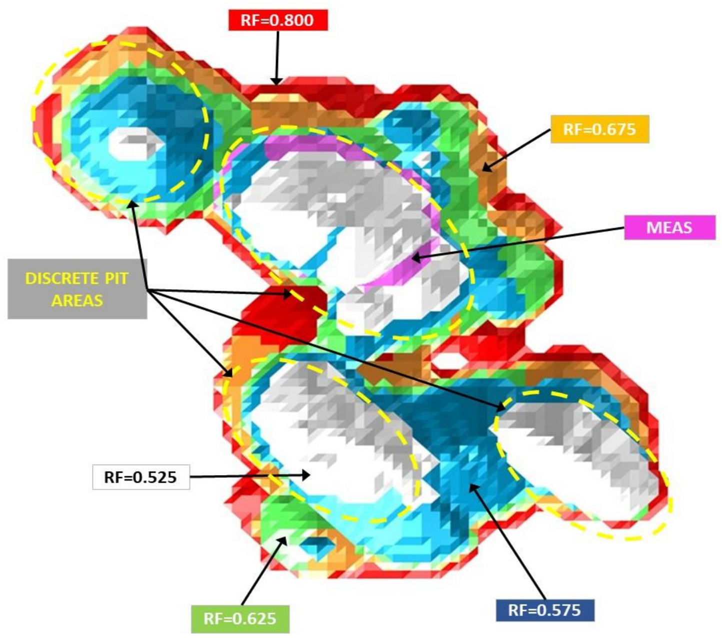
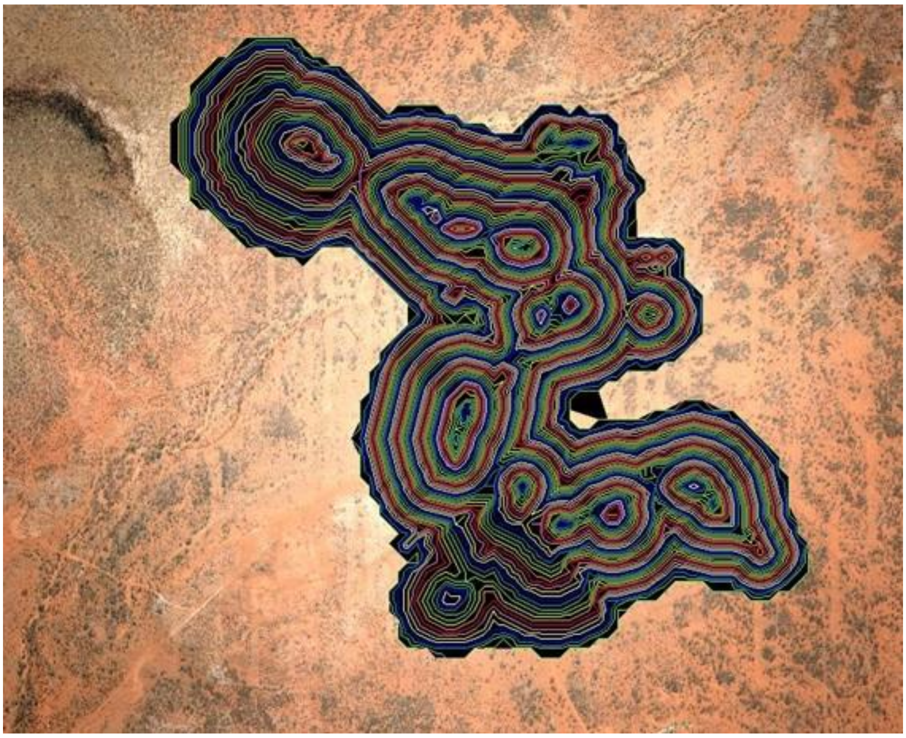


Figure 11
MI Shell 20, RF=0.80



3.3 Mine Design

3.3.1 Design Criteria

The design criteria for both pit and dump designs include:

- Adherence to geotechnical slope design parameters as established by AMC.
- Haul roads crossing over creeks or creek diversions have been minimised.
- Ramp locations should be located for practical access to dumps and stockpiles and should allow for minimal rework or re-establishment during pit stage merging.
- A minimum mining width for cutbacks, or pit stages, and the bottom of pits, of 40 metres
- Haul road widths are 30 metres for dual lane traffic and 21 metres for single lane. Single lane roads and ramps are limited to a length of 100 metres. All ramps have a maximum gradient of 10%.
- Waste dumps and stockpiles have been designed at 10 metre lifts using a 37° angle of repose and 5 metre berms, and allowing for a final rehabilitation slope of 16°, incorporating a concave profile of 14.5° and 18°. The maximum height for all dumps and stockpiles is the 720 m level, approximately 50 to 60 metres above the 660 m existing ground level.

3.3.2 Open Pits

The final proposed mining area layout is shown in Figure 12, and pit inventory is summarised in Table 18 and includes a breakdown of the stockpiled material.

Table 18
Pit Inventory

Material	Mt	P_2O_5 (%)	TREO (%)	NdPr Enrichment (%)
Ore for Processing	**19.2**	**13.2**	**2.97**	**26.4**
Inferred to Stockpile	2.8	11.6	2.58	26.5
NP1 to Stockpile	0.4	9.6	4.60	26.0
NP2 to Stockpile	9.3	11.8	2.67	26.6
Benign Waste	71.7			
NORM Waste	68.6			
Total	**172.1**			

The final design is divided into seven pit stages, either by discrete pits or by cutback, which form the basis of the production schedule.

The first three stages, indicated on Figure 12, are independent of each other with the starter pit being located in the northern portion of the deposit and centred on the Measured Resources.

Stages 2 and 3 are in the southern parts of the deposit and comprise independent pits to Stage 1. Stage 4 is the connection of the second and third pits and includes an overall deepening to the 540 bench, a total depth of over 100 metres.

The fifth stage is a return to the northern pit and a cutback to final limits on the northern, eastern and a portion of the southern walls. This pit stage is also the first whose ramp systems are directed to the northern waste dumps.

Stage 6 is the stand-alone north-west pit, and Stage 7 is the connection of the northern and southern pits into a single pit. The final pit dimensions are 1.6 kilometres long, 800 metres wide at its widest point and extending to a depth of 190 metres.

3.3.3 Dumps and Stockpiles

The general location of the waste dumps and long-term stockpiles was provided from previous studies along with the design criteria to encapsulate the naturally occurring radioactive material (NORM) waste. Each of the two waste dump locations have been divided into a number of discrete dumps to allow staged encapsulation and progressive rehabilitation.

The long-term stockpiles were designed to store all the Inferred, NP1 and NP2 material for the life of mine (LOM) with no consideration for this material to be processed at this stage.

The dump and stockpile designs are shown in Figure 12.

Figure 12

Mining Area Layout

3.4 Mining Methods and Equipment Selection

All mining and associated activities are planned to be undertaken by a mining contractor.

The mining contractors who submitted budget prices for the study proposed equipment that included 100 tonne class excavators and either 90 tonne or 136 tonne rear dump trucks, both of which are suitable for the designed pits.

All material to be mined is planned to be drilled and blasted. If any free-dig material is available, this will be assessed at the time to ensure no loss of productivity occurs by no blasting.

Waste mining will be undertaken as a conventional excavator-truck operation and is planned to be undertaken as an ongoing pre-stripping operation, where when one stage encounters sufficient ore to sustain mill feed then the focus of waste mining moves to the next stage.

There are large areas of waste associated with the stage designs which could be mined with larger equipment on higher benches of up to 10 metres if desired. This could reduce operating costs in drilling, blasting and hauling. However, there would need to be input from the grade control geologists to ensure that the mining is slowed as the ore zones are encountered and then the mining methods revert to being more selective.

It is expected that the ore will require selective mining and significant input from grade control geologists on a flitch-by-flitch basis. This will most likely require the bench height to be no greater than 5 metres with mining being undertaken on three 2 metre flitches when heave is included. All ore mined is stockpiled on the run of mine (ROM) pad for blending, and no direct feed of the mill occurs. ROM material is loaded onto road trains by front end loader and delivered to the process plant approximately 8.5 kilometres south of the ROM pad.

The division of the ROM stockpiles will be driven by TREO grade, which governs potential revenue, or by P_2O_5 grade, which drives concentrate production. However, the scheduling has shown that the different material type classifications also can have an effect on the concentrate and TREO production, therefore stockpiling will also be undertaken according to material type ratios.

The haulage of the ore from the ROM stockpile to the process plant using conventional road trains will be undertaken by the mining contractor as part of the mining contract at a haulage rate up to 1.0 Mtpa.

3.5 Production Scheduling

Mine scheduling was completed using Geovia MineSched software (MineSched). The scheduling framework used includes mining areas for each pit stage and a series of stockpiles for ore blending. To allow reporting of the material type classifications additional stockpiles for the Inferred material are used.

Staged waste dump scheduling was also completed within MineSched to manage the encapsulation process on a lift-by-lift basis.

3.5.1 Production Targets

The mining schedule was driven to achieve a balance between a number of constraints:

- Measured Resources priority for mining and mill feed.
- A maximum milling capacity of 1,000,000 tpa.
- A PAII ratio of less than 0.3.
- A target concentrate production of 300,000 tpa.
- A maximum TREO production of 14,100 tpa.

The constraints were prioritised in the scheduling to primarily target Measured Resources and then to maximise concentrate production. Maximising concentrate production will flow through into TREO production whereas maximising the front-end throughput will likely cause bottlenecks in both concentrate and TREO production.

In line with these targets the mining rate was managed to defer as much mining, and therefore cost, as possible and to maintain ROM stocks within reasonable levels of approximately 4-6 weeks supply.

In addition to the overall constraints a production ramp up schedule was also built into the first three years (refer Section 8.1).

To manage ore variability, the whole schedule was run on a quarterly basis which allowed the periodic milling tonnages to approximate the results of the variability test work previously undertaken.

For the base case DFS production schedule, only Measured and Indicated Resources were used for mill feed, and all Inferred Resources within the pit designs were placed in long-term stockpiles.

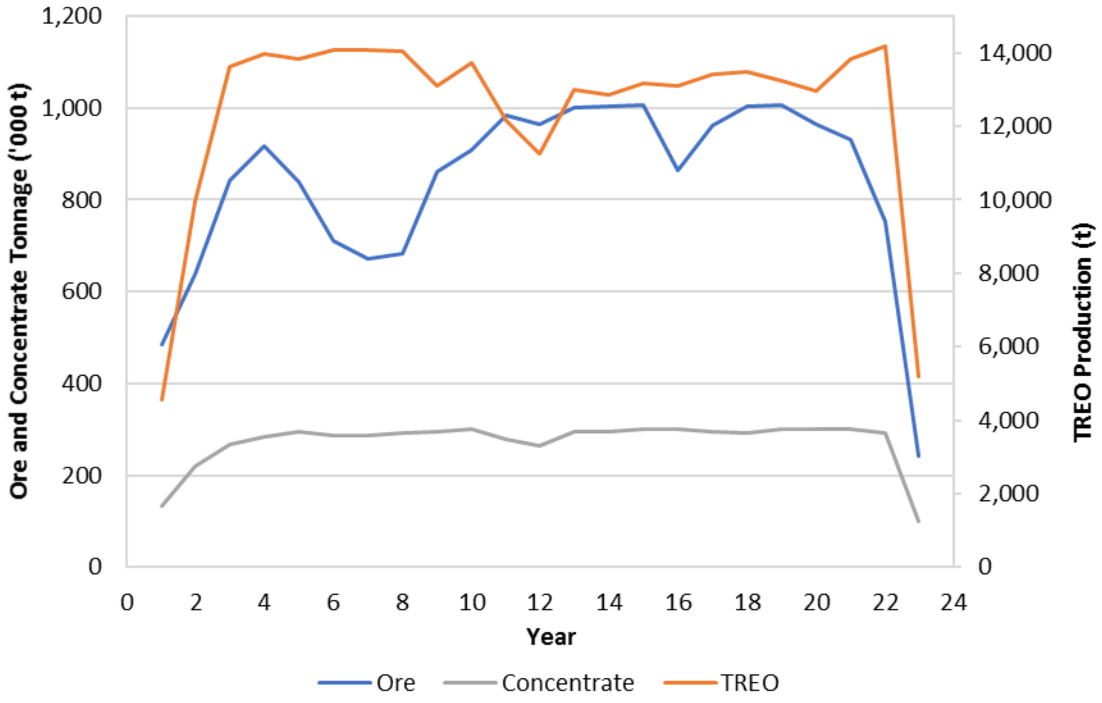
3.5.2 Processing Outcomes

The base case schedule adheres to the five main constraints and achieves a 23-year mine life. At various periods within the schedule each of the three constraints is the dominant limitation, depending on the ore quality being mined.

The plant can run at this steady state TREO production until year eight, when mining is predominantly in Pit 4. From year nine the constraint moved to a combination of concentrate production and front-end milling capacities. Beyond year 12, the plant can fully utilise the concentrate circuits with this area being the main production driver for the remaining mine life.

The results of scheduling utilising the constraints are summarised on an annual basis in Figure 13.

Figure 13
Process Plant Ore Feed, Concentrate Production and TREO Production



3.5.3 Mining Outcomes

Mining rates were driven by the processing constraints along with the requirement to minimise, that is defer, waste mining while maintaining adequate ROM stockpile levels.

These constraints drive an average annual mining rate of 3.2 Mtpa for the first seven years before rising to 8.0 Mtpa in year 10. This rate will be maintained until year 15 when the final pit stage will be commenced, at which time the mining rate will rise to 11.2 Mtpa. This rate will be the peak mining rate for the LOM and will be required to be maintained for less than three years before the mining rate will gradually reduce towards the end of the mine life.

The key development activities necessary to achieve the schedule or are outcomes of the schedule are:

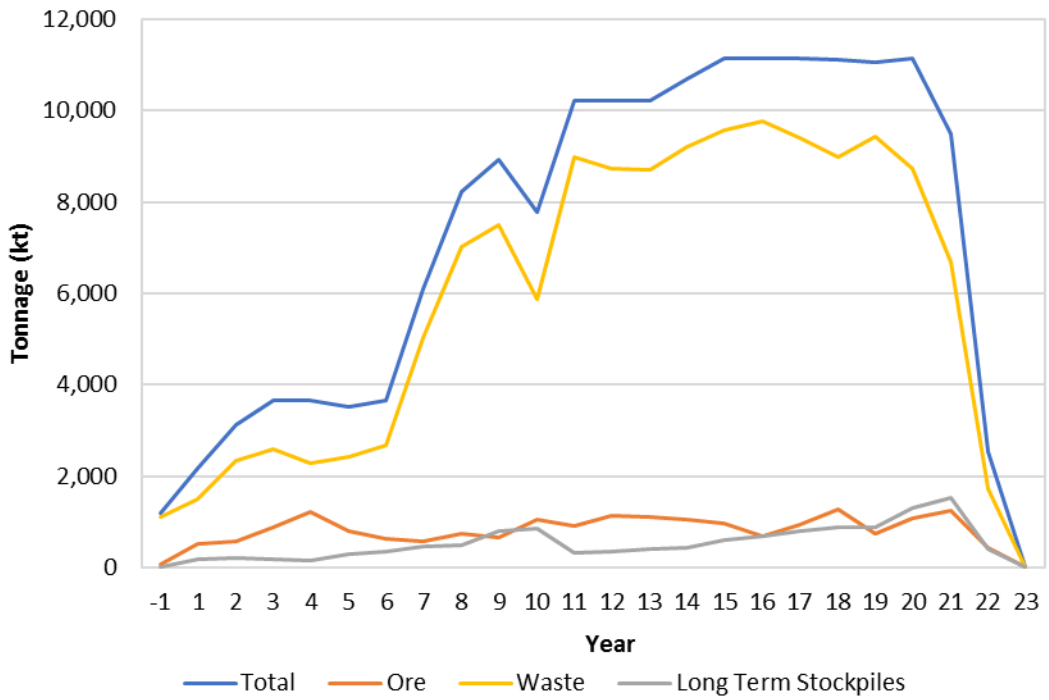
- The initial Kerosene Camp Creek diversion is required before mining commences to allow access to the first stage.
- All waste mined is to be placed on the southern waste dump with the NORM waste being encapsulated progressively.
- The southern waste dump can be developed in a number of stages allowing both progressive encapsulation and rehabilitation.
- An initial pre-strip period of eight months will be undertaken in pit Stage 1 which places 70,000 tonnes of ore on the ROM pad.

- The first pit stage lasts five years with stripping on Stage 2 commencing in year six, which in turn will last another three years.
- At the end of year 10 mining will be in pit Stage 4, with the first three completed and the third stage of the southern dump being encapsulated.
- In year 14 mining will commence in Stage 6, requiring the commencement of the northern waste dump and the completion of the second stage creek diversion.
- Stage 5 mining will be completed in year 18, Stage 6 in year 19, and all mining will be completed by year 22.

The mining outcomes of the schedule are summarised in Figure 14.

Figure 14

Total, Ore, Waste and Long-Term Stockpile Mining Quantities



3.5.4 Upside Case Production Schedules

The base case production schedule only processes Measured and Indicated Resources to allow estimation of Ore Reserves. Any Inferred Resources mined are stockpiled and not processed. While this is not a practical solution it ensures that no value is attributed to this material. In addition to Inferred Resources the material classified as 5A2 is a non-preferred ore type but is a significant quantity and grade.

To account for the potential value in both the Inferred Resources and 5A2 material an upside schedule was produced.

Inclusion of Inferred Resources

The only Inferred Resources included in the upside case is that which falls within the pit design, and no modifications were undertaken to target Inferred Resources. The total Inferred Resources within the pit design is 3.0 Mt. These resources are included in the processing blend when mined and not placed on stockpile as for the base case.

Inclusion of Material Type 5A2 (NP2)

The non-preferred 5A2 material was included in the upside case to evaluate its potential. For this case the geometallurgical relationships for the prediction of beneficiation performance for material type 5A1 were utilised as there had been a small number of flotation tests carried out on material type 5A2 and these were included in the development of the 5A1 relationships with indications that the material behaved in-line with the predicted performance, albeit with lower TREO recovery.

For the upside case this material was rehandled from stockpile when all mining was completed. This rehandling adds a further 8.7 Mt and extends the processing life by 9.5 years.

3.6 Mining Cost Estimate

The mining cost estimate was derived from budget price submissions from mining contractors who were provided with the data from previous studies and aligned with the production schedule. The major cost centres that were modelled were:

- Mining fixed charges.
- Clearing and topsoil stripping.
- Drilling and blasting.
- Load and haul.
- Ore rehandle and haulage to the process plant.
- Rehabilitation.

In addition to the unit rates provided by the contractors an estimate was made for the required equipment fleet sizes and the timing of fleet expansions. These estimates allowed the build-up of the mobilisation and fixed charges to be staged to match the production schedule.

The manning levels were estimated from the equipment utilisation and contractor submitted management and supervision numbers. These values were then factored for the likely shift rosters taking into account where machines may be only operating single shift.

3.7 Ore Reserves

The overall Project financial model was prepared by Arafura using inputs from the mining schedule cost model as well as detailed processing, tailings disposal, power, water, camp infrastructure, logistics and other costs. Mining Plus reviewed the cash flow model with Arafura to confirm that the Project has a positive cash flow outcome.

The Ore Reserves estimate is shown in Table 19.

Table 19
Nolans Project Ore Reserves
Announced 7 February 2019

Classification	Mt	TREO (%)	P_2O_5 (%)	NdPr Enrichment (%)
Proved	4.3	3.1	13	26.1
Probable	14.9	2.9	13	26.5
Total	**19.2**	**3.0**	**13**	**26.4**

Note: Numbers may not compute due to rounding. "NdPr Enrichment" is the proportion of TREO comprising neodymium oxide Nd_2O_3 and praseodymium oxide Pr_6O_{11}.

Mining Plus utilised the mining costs derived from contractor submissions and processing costs and other information supplied by Arafura and from the consultants listed below. Whittle software was used to derive a number of economic pit shells for each deposit. The shell that produces the maximum DCF was selected as the basis for open pit work.

Pit designs were undertaken using Surpac software, allowances were made for the recommended pit wall angles, and pit ramps suitable for the selected mining equipment were incorporated. As the final pit designs were derived, a small amount of Inferred Resources was included within the mining inventory. This material is excluded from the Ore Reserves and mill feed in the schedule for reporting purposes. The proportion of this material in the mining inventory is less than 12%, and the Project does not rely on the inclusion of Inferred Mineral Resources as mill feed in order to be feasible.

The Ore Reserves are based on information complied by the following:

- Revenue prices, based on historical averages and forward estimates, based on independent marketing reports provided by Arafura.
- Processing recoveries based on the geometallurgical model developed by Arafura.
- Mineral Resources estimate by Arafura.
- Pit optimisation and mine design by Mining Plus.
- Geotechnical review and design parameters by AMC.
- Capital and operating costs developed as part of this DFS.

4 METALLURGY

Substantial process development and process definition test work has taken place for the project flowsheet. This work has included batch test work programs, locked cycle test work and continuous pilot scale test work completed for all plant areas including beneficiation, phosphate extraction, rare earth extraction, rare earth processing, and rare earth separation.

The primary objective of the batch and locked cycle test work was to complete a series of tests at differing conditions or parameters from which decisions could be made to rule out certain parameters or to continue additional detailed testing to confirm and optimize parameters and conditions. Variability test work was completed to assess the effect of varying ore, concentrate and recycled acid types on process performance. The objective of the pilot plant test work carried out during 2016 to 2018 has been to confirm the process viability and effect of some recycle streams, and to generate additional engineering data for plant design including filtration rates and materials of construction choices.

4.1 Metallurgical Batch Test Work

4.1.1 Comminution and Other

Comminution test work has been carried out for the ore and the hanging wall (waste) material, including:

- Bond impact crushing work indices.
- Bond ball mill work indices.
- Bond rod mill work indices.
- Bond abrasion indices.
- SMC (SAG milling) test work.

In general, the results indicated that the ore is soft whereas the waste is reasonably competent.

In 2015 these test results were used to carry out preliminary modelling of the comminution circuit. In 2018 the comminution circuit was remodelled due to updates to the geological and mining model indicating that better waste classification and identification should be possible to enable more selective mining throughout the Nolans orebody. Preliminary test work also indicated a potential for further rejection of the waste material by the addition of an ore sorter, however additional testing would be required to validate and justify its inclusion in the flowsheet.

In addition to the comminution test work the following physical test work has also been completed on various samples:

- Bulk density determinations.
- Rheology testing of ore concentrate and tailing slurries.
- Material flow property testing of concentrate.

4.1.2 Flotation

Metallurgical test work programs have been conducted from 2011 to early 2015 to refine the beneficiation flowsheet (previously designed around the hydrochloric acid pre-leach flowsheet) with the focus to reduce mass recoveries to concentrate to assist in decreasing reagent requirements in downstream processing. These test work programs were conducted at multiple commercial laboratories with the involvement of various consultants.

Through this bench scale test work, the beneficiation flowsheet has evolved to a relatively simple rougher flotation with gravity recovery flowsheet to produce a high phosphate concentrate. Following the adoption of this flowsheet the optimisation of various parameters, such as grind size, temperature, reagent selection, reagent dosage and pulp density, was carried out.

The majority of samples used in the batch beneficiation test work programs were sourced from large diameter Bauer drilling intervals, ranging in head grade from 0.7% to 6.1% TREO and 3.1% to 24.8% P_2O_5 and also representing the full range of geological material types.

The 2016 bench scale program was undertaken using a shaking table for gravity separation followed by flotation of the gravity concentrate. This was successful in producing a high recovery to a high-grade concentrate. However, during the pilot program (described below) a similar performance was not achieved using spirals for the gravity separation. Sighter test work was subsequently carried out using flotation only of ore resulting in greater than 95% TREO recovery and greater than 98% P_2O_5 recovery with mass rejection of between 45% and 55%. This simplified flowsheet was adopted for the Project.

4.1.3 Extraction

Process development for the PAPL flowsheet was completed at SGS Australia Pty Ltd (SGS) in 2015. The process development work focused on the phosphate extraction circuit and the extraction of rare earth elements from the pre-leach residue. This program was completed in seven phases that investigated the following:

- Pre-leach sighter tests investigating the impact of various process parameters and configurations, including the recovery of rare earth elements from pre-leach liquor.
- Phosphoric acid regeneration sighter tests to assess the impact of various parameters on rare earth losses to gypsum.
- Locked cycle test work.
- Phosphoric acid purification test work.
- Pre-leach residue ‘cracking’ and leaching.
- Purification and precipitation of rare earths.
- Chloride leach and purification of the rare earth chloride intermediate product.

After the process development work, a process definition stage was completed that aimed to further define the process chemistry and support the design criteria for the preferred PAPL flowsheet configuration. The PAPL process definition stage was carried out at SGS in 2015 and 2016 in six phases:

- Pre-leach loop including pre-leach, rare earth recovery and phosphoric acid regeneration.
- Rare earth sulphate precipitation.
- Ion exchange resin loadings (pre-leach solution and regenerated acid).
- Full mixed-acid locked cycle.
- Phosphoric acid purification and product concentration.
- Rare earth sulphate dissolution and purification.

The above development and definition test work programs were completed using for two different concentrates with a focus on developing reliable design criteria for the process chemistry. This work revealed that the PAPL flowsheet was viable for treating Nolans material. Key outcomes of the test work were:

- Rare earth leaching in the pre-leach occurred at approximately 30% of the feed content with a mass loss from concentrate of approximately 50%.
- Heating the pre-leach solution to boiling point precipitated rare earths with varying rare earth recovery extents up to 10% for yttrium, 20% for heavy rare earths (HRE), 60% for samarium-europium-gadolinium (SEG), and 80% for light REEs.
- MGA phosphoric acid could be generated by the PAPL process.
- A low temperature acid bake and water leach was the most effective method for mobilising REEs into solution.
- The selected precipitation agent was effective in promoting precipitation of rare earths from solution without neutralisation of the acid following water leach.

Following the definition test work program, phosphoric acid purification by ion exchange development was conducted at SGS in 2017, and at ALS Ammtec (ALS) in 2018.

Additionally, two process optimisation programs were conducted at SGS between 2016 and 2018 to determine the optimum process conditions across all unit operations of the phosphate extraction, rare earth extraction, and rare earth processing areas of the flowsheet and support the design criteria in advance of piloting. These optimisation programs were based on two concentrate samples generated from pilot ore using optimised beneficiation conditions, the first via batch processing, and the second from the beneficiation pilot.

4.1.4 Rare Earth Separation

Several bench test work programs have been conducted for the separation and recovery of rare earth products from a rare earth chloride solution as produced by the rare earth processing flowsheet. The early bench scale testing was carried out to start process development, define the process concept, and to determine the required number of stages in solvent extraction (SX). More recent batch test work has been completed to validate the SysCAD process model and to support the chosen flux rate for settler design.

The initial phases of batch test work were conducted at Australian Nuclear Science and Technology Organisation (ANSTO) between 2008 and 2010. The aim of these initial phases was to develop and refine a two-stage SX process for generation of five rare earth streams via two separate SX circuits with SEG and HRE streams recovered in SX 1, cerium precipitation from the SX 1 raffinate prior to SX 2 which recovered NdPr to a strip solution and a mixed La/Ce raffinate. The batch test work was successfully completed and included producing pH isotherms, distribution isotherms and kinetic curves. This test work laid the foundations of subsequent pilot testing which produced five separated products from four SX circuits.

Following the batch and pilot test work carried out at ANSTO, Ce removal was proposed to be carried out in rare earth processing prior to SX to reduce costs. In addition, three SX stages were proposed in the design for recovery of separate SEG/HRE, NdPr and La products.

This proposed flowsheet was tested at SGS to confirm the information and assumptions in the in-house SX optimization SysCAD model and investigate the phase separation rates for designing the commercial mixer-settlers.

4.2 Variability Test Work

Variability test work has been completed for the beneficiation, phosphate extraction and rare earth extraction sections of the flowsheet. The variability work has focused on determining the difference between various ore, concentrate and regenerated phosphoric acid on the chemistry of the process. Later stages of the variability testing for beneficiation were aimed at providing a basis for the geometallurgical model based on a range of individual core samples selected to represent the geological material types and the full range of anticipated grades.

4.2.1 Beneficiation

Three stages of beneficiation variability test work have been carried out on the final flotation only flowsheet with different sample blends, types and locations selected for different stages of testing. The overall purpose was to determine geometallurgical relationships that can be used for pit optimisation for DFS. However, each stage had a different purpose:

- Stage 1 was to determine the flotation conditions for different ore types.
- Stage 2 was to develop a geometallurgical model for the pre-feasibility study feeding into pit optimisation modelling, based on flotation performance of variability PAPL samples.
- Stage 3 was to determine a geometallurgical model for the DFS that covers all the material types, validation of the model and testing of final flotation conditions, including testing performance in site raw water.

Stages 1 and 2 were carried out at ALS and Stage 3 was carried out at Nagrom Metallurgy.

From these three stages the flotation flowsheet was demonstrated to be applicable to all PAPLP ore types. In addition, geometallurgical relationships were developed (as described in Section 3.2) that describe the flotation performance of the phosphate, rare earth species and key metallurgical contaminants.

4.2.2 Extraction

The extraction variability test program was conducted in two phases. The first phase was to determine the influence that natural variations in the chemistry and mineralogy of the concentrate feed material has on the performance of pre-leach, acid bake and water leach operations. The second phase was to determine the influence of the primary impurity elements in the phosphoric acid on the performance of the pre-leach and rare earth recovery operations.

Phase one tested a range of representative concentrate samples using a single representative phosphoric acid leach feed solution (from the phosphate extraction pilot program) in the leach whereas phase two made use of a single representative concentrate sample (from the flotation pilot plant) to test the effects of the phosphoric acid at varied primary impurities. As a result of the extraction variability test work it was determined that the ore feed to the extraction plant should be blended to control the impurity ratio (being the molar ratio in the pre-leach phosphoric acid of 2Mg+3Al+3Fe to P) to be less than or equal to 0.3.

4.3 Metallurgical Pilot Test Work

Pilot-scale test work programs have been designed for all stages of the process plant. The pilot programs have investigated the operability of the various process stages as well as the effect of some of the major recycle loops on the chemistry of the process. Further, the pilot campaigns have generated material for vendor testing to define filtration rates, centrifuge operability, materials of construction, off-gas compositions and radionuclide deportment.

4.3.1 Beneficiation

ALS conducted continuous pilot plants for both the comminution and beneficiation of bulk ore samples, using a representative composite ore sample that was typical for years two to four of the mine plan at the time of sample preparation (15 tonnes based on the 2013 mine plan). The aim of the piloting test work was to demonstrate performance of the beneficiation circuit, generate feed for the phosphate extraction pilot investigations, and to generate data for engineering of the production facility.

The flotation pilot operated on a full open circuit with four rougher cells followed by re-conditioning and a scavenger cell. The rougher and scavenger concentrates were combined to generate a bulk concentrate for later phases of piloting.

During the pilot, several adjustments were made to reagent additions to increase recovery of REE to the concentrate. Six surveys were taken during the pilot, three of which occurred under the same reagent conditions. Based on a target of 80% recovery of REE, the pilot results suggest a target of 54.9% mass recovery, resulting in a REE grade in the concentrate of 5.79%. The values used for process design are conservative, at a mass pull of 54.6% and a REE grade of 5.6%; resulting in a recovery of 77%. Phosphate recovery to the concentrate under the conditions used in the design was 91.8% from the pilot plant data.

4.3.2 Phosphate Extraction

Two pilot plant programs were carried out for the development of the phosphate extraction flowsheet. Both programs included phosphoric acid pre-leach, rare earth recovery and phosphoric acid regeneration unit operations.

The initial pilot investigation was a closed loop pilot of the three unit operations that recycled the regenerated phosphoric acid back to the pre-leach. This pilot was carried out at relatively small scale (1.9 kg/h dry feed solids) and did not pilot the complexity of the counter-current leaching or seed recycle streams for rare earth recovery or phosphoric acid regeneration. The recovery of REE from the pre-leach solution in the plant design were taken from the worst-case numbers obtained in the closed circuit pilot.

During the closed circuit pilot, corrosion coupons were placed in leach, recovery and regeneration to determine corrosion rates and materials of construction options for these areas. Following the closed loop rare earth extraction pilot campaign, a portion of the regenerated phosphoric acid bleed was sent to Prayon Technologies for concentration to MGA phosphoric acid (54% P_2O_5). The testing included precipitation of residual calcium, evaporation of water and maturation (ageing) of MGA phosphoric acid.

The second pilot investigation incorporated the full complexity of the recycle streams required in the commercial process for each unit operation but used a synthetic phosphoric acid feed rather than operating as a closed loop with respect to phosphoric acid regeneration. The scale of the second pilot was increased substantially (33 dry kg/h) to generate sufficient feed for the downstream (sulphation) pilot.

Under the tested conditions in the open circuit pilot, REE extraction from the concentrate varied between 10% and 40%, with no apparent relationship to the liquid to solid (L/S) ratio in the leach. On this basis, the PAPL design of 38% REE extraction in the pre-leach is considered conservative.

Centrifuge tests were completed by Alfa Laval for both pre-leach stages to assist with equipment sizing for the counter-current centrifuge washing used for the design. At typical G forces for commercial centrifuges (1800G), the Stage 1 residue was thickened to 68% w/w solids, and the Stage 2 residue to 52% w/w solids with no free draining moisture from the cake.

Ektimo was contracted to complete gas concentration analysis for the headspace of the tanks during the closed circuit pilot campaign. Evolution of hydrofluoric acid gas in the headspace of rare earth recovery was noted during the pilot and provisions for venting the tanks in this reaction train to a caustic scrubber have been included in the plant design.

4.3.3 Sulphation

The sulphation pilot plant was run at SGS over four days for the sulphation bake step of the process. The acid mixer used was a pug-type mixer supplied by a local engineering firm. The acid bake unit was a Komline Nara paddle dryer and the cooler was an Andritz Gouda paddle cooler. The use of two different vendors for the paddle dryer/cooler technology allowed an assessment of the units to aid in selection of the preferred supplier.

An important goal of this pilot was to assess the material handling properties of the material progressing through the sulphation train, which have been experienced at other rare earth processing facilities, and demonstrate the significant advantages of the use of paddle dryers over traditional kilns. Lessons learned during the pilot for improving material handling were noted and will be incorporated into the detailed design to promote reliable operation of the commercial facility.

Analysis of corrosion coupons over the short-term pilot suggested that relatively low-cost alloys such as SAF 2507 or LDX 2101 could potentially be used as a material of construction for the sulphation bake unit. Longer term corrosion test work will be carried out to improve the accuracy of these results and determine if a duplex or stainless steel could be used in place of nickel alloy as a material of construction for the sulphation bake unit.

The sulphation pilot has been successfully completed and preliminary analysis of available results indicate that the performance of the sulphation pilot was in-line with expectations and the design developed in the DFS. In addition, invaluable information was gathered relating to the design of the sulphation area of the process plant, particularly with respect to materials handling, off-gas handling, rheology and shutdown and cleanout procedures.

4.3.4 Water Leach

The water leach pilot plant was operated at SGS over five days for the water leach step of the process. The water leach repulp tank had a very short residence time, and the water leach tank residence time was controlled via a fixed overflow discharge point. The water leach slurry was dewatered in an Alfa Laval centrifuge. The centrate was filtered through cartridge filters prior to being charged directly to sulphate precipitation. The water leach slurry was collected in buckets before being re-pulped and filtered through an Ishigaki filter-press. The addition of wash water was controlled to target a set REE concentration in the water leach liquor. A chiller unit was used to cool the water leach feed to target a 30°C reaction temperature in the water leach tank.

The filtered water leach liquor was charged directly to sulphate precipitation. In sulphate precipitation, rare earth sulphates are selectively precipitated by the addition of a precipitation agent to the leach liquor. The rare earth sulphate crystals were subsequently filtered through a candle filter.

The main aims of the water leach pilot were to collect filtration and centrifuge design data and to test the quality of the rare earth sulphate product. Additional information around controlling the counter-current leach with recirculating liquor flows were noted during the campaign and will be incorporated into the design to promote reliable operation of the commercial facility.

The water leach pilot has been successfully completed and preliminary analysis of available results indicate that the performance of the water leach pilot was in-line with expectations and the design developed in the DFS.

4.3.5 Rare Earth Processing

The rare earth processing pilot plant was run at ALS over 12 days for the production of refined rare earth hydroxide (Phase 1, run over five days). The hydroxide product was then selectively dissolved in hydrochloric acid via the rare earth hydroxide dissolution stage in a second processing pilot (Phase 2, run over seven days) to generate the cerium hydroxide product and a rare earth chloride liquor which, following purification and concentration, will be used to feed to the separation pilot.

The rare earth processing pilot was successfully completed, and analysis of preliminary results indicate that the performance of the rare earth processing pilot met or exceeded performance expectation and confirmed the DFS design assumptions.

4.3.6 Rare Earth Separation

Four mini-pilot plant trials were completed in 2011 and 2012 for continuous testing of the SX circuits. The pilot program was designed to produce the following five loaded strip product streams at 99% w/w target rare earths to total REE purity and a maximum of 1% w/w non-REE impurities:

- SEG strip product.
- HRE strip product.
- NdPr strip product.
- Ce strip product.
- La strip product.

Actinium was rejected in the final SX 4 (La) raffinate. The final actinium-bearing raffinate was then rejected as waste.

The mini-pilot investigations for each SX circuit were run individually, with a break point at each raffinate and strip product. Each pilot operated on a continuous basis testing the entire organic loop with saponification pre-loading included into the loop. Rare earth oxides were produced from all four strip product streams in batch tests via oxalate precipitation and calcination at 1000 °C.

The operation of these mini-pilot investigations was successful in achieving the majority of the aims of the programs with some modifications to the circuit carried out during the mini-pilot run.

A final separation pilot, processing rare earth chloride feed from the ALS rare earth processing pilot program is in the process of being planned and will further validate the mini-pilot plant results.

4.4 Process Development and Selection

Based on the combination of all completed test work the optimised process flowsheet was selected. The selected flowsheet takes into account critical learnings from the various batch tests, variability tests and pilot runs. The selected flowsheet incorporates a number of industry-standard processes along with a small number of innovative processes to provide a flowsheet that is complimentary to the ore and provides a high level of process efficiency.

The overall process is described in Section 5.2.

5 PROCESSING

5.1 Design Basis

The facility has been designed for a life of 30 years.

The overall plant comprises the following plant areas:

- Mining – The mine area will be located approximately 8.5 kilometres from the main process plant. Ore will be received from the mine haul trucks to the ROM pad where ore will be stored for transport to the process plant.
- Comminution and Beneficiation – This area will be located at the main process plant, the ROM ore will be crushed, milled and beneficiated using flotation producing a concentrate, which will be feed into the extraction plant, and tailings, which will be sent to the Residue Storage Facility (RSF).
- Extraction Plant – Located at the main process plant, the hydrometallurgical processing area will consist of all the unit operations that separate the REE from gangue minerals to produce an MGA phosphoric acid by-product, a cerium hydroxide product, and a rare earth chloride liquor which will be fed into the separation plant.
- Separation Plant – Located at the main process plant, the solvent extraction facility and product handling area will separate the SEG/HRE and NdPr into final rare earth products.
- Reagents – Located at the main process plant, the reagents area will store and deliver all the necessary reagents used in the beneficiation, extraction and separation areas of the plant. The reagents area will also include a sulphur burning acid plant and a chlor-alkali plant (installed in years six and seven of operation).
- Services and Utilities – Located at the main process plant, this area will consist of all the major services for the plant. This will include raw water and other water services, power generation, steam generation, natural gas supply and distribution, and compressed air.

Plant availability for each major plant area is shown in Table 20.

Table 20
Plant Availability

Plant Area	Availability (%)	Hours per annum
Mine	82.2	7,200
Beneficiation & Crushing	91.3	8,000
Extraction Plant	85.6	7,500
Separation Plant	85.6	7,500

The beneficiation plant and associated equipment has been designed to process a maximum of 1,000,000 tpa of ore. This is to cater for variation in ore grade over the LOM.

The process plant has been designed for 300,000 tpa of concentrate which relates to a nominal 13,343 tpa of TREO equivalent products with a potential maximum of 14,100 tpa depending on the mining schedule. Table 21 is a breakdown of the specifications and average tonnages of the rare earth products.

Table 21
Rare Earth Products

Product	TREO %	REO/TREO %	Average REO* t	Average Product t
Cerium Hydroxide	>95%**	>95%	8,383	10,271
NdPr Oxide	>99%	>99%	4,357	4,379
SEG/HRE Carbonate	>99%**	>99%	603	1,064
Total			**13,343**	**15,714**

* Average production is calculated as the arithmetic annual average following the anticipated three year ramp up period and excluding the partial final year of production.

** % TREO for hydroxide and carbonate products is based on an as calcined (converted to an oxide product) basis.

The by-product of the process will be P_2O_5 contained in MGA phosphoric acid with an average annual production of 73,336 tpa P_2O_5 in 135,808 tpa of MGA phosphoric acid.

Production by operating year is provided in Table 22.

Mining envelope data, which includes various permutations of changes in head grade, ore composition, and concentrate variability over the LOM over short and long-term durations has been considered in the design, with resultant impacts on equipment sizing factors and specific area design margins.

Gypsum and beneficiation tailings are combined and will report to a combined cell in the RSF. Decant water will be recycled to the beneficiation plant.

The neutralised residue from the extraction plant contains most of the thorium and uranium present in the processed ore and also contains a mixture of other gangue elements, waste brine and separation plant residue. This will be stored in a second cell in the RSF.

Water will be sourced from borefields located south-west of the process plant. The anticipated raw water requirement rate is 3.4 GL per annum.

5.2 Facility Description

Figure 15 and Figure 16 shows the overall process schematic and Figure 17 shows the proposed process facility layout. This section describes, at a high level, the process and its intent.

Table 22 Production by Operating Year (Base Case Mining Schedule)													
Year		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Ore Processed	kt	484	639	841	918	839	710	670	682	862	910	984	964
Head Grade													
P_2O_5	%	12.6	13.6	12.9	12.4	13.6	16.1	16.9	16.1	14.1	14.1	11.5	10.9
TREO	%	3.2	3.4	3.2	2.9	3.0	3.5	3.7	3.5	3.1	3.1	2.6	2.5
Beneficiation													
P_2O_5 Recovery	%	65.4	75.7	74.2	74.4	77.6	75.9	77.4	81.7	71.4	68.1	71.6	72.2
TREO Recovery	%	65.1	74.7	71.6	71.4	74.9	77.3	77.9	79.6	67.3	66.3	65.0	63.0
Concentrate	kt	133	220	268	285	296	287	288	293	295	301	280	265
Final Production													
Ce oxide	t	3,057	6,297	8,590	8,797	8,696	8,809	8,780	8,756	8,177	8,579	7,693	7,120
NdPr oxide	t	1,279	3,226	4,410	4,526	4,517	4,647	4,661	4,668	4,337	4,536	3,926	3,612
SEG/HRE oxide	t	221	454	618	634	630	634	631	636	589	616	546	507
TREO	t	4,557	9,976	13,618	13,958	13,842	14,090	14,072	14,060	13,103	13,731	12,165	11,240
P_2O_5	kt	34	56	69	72	75	74	75	76	74	74	69	64
MGA Phosphoric Acid	kt	63	104	127	134	139	136	138	141	136	138	127	119

Table 22

Production by Operating Year (Base Case Mining Schedule)

Year		**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**Total**
Ore Processed	kt	1,000	1,003	1,007	864	961	1,003	1,007	963	930	754	243	**19,237**
Head Grade													
P_2O_5	%	11.6	11.7	11.7	13.2	12.1	11.5	11.9	13.2	14.5	16.4	17.1	**13.2**
TREO	%	2.6	2.6	2.6	2.9	2.8	2.7	2.7	2.8	3.1	3.5	3.7	**3.0**
Beneficiation													
P_2O_5 Recovery	%	74.5	73.8	74.1	78.4	75.0	73.3	72.7	69.0	65.1	70.8	73.6	**73.3**
TREO Recovery	%	67.3	67.3	67.9	71.9	68.5	68.1	67.3	64.7	64.9	72.0	74.6	**69.7**
Concentrate	kt	295	295	300	300	295	293	299	300	300	293	101	**6,282**
Final Production													
Ce oxide	t	8,219	8,119	8,309	8,262	8,473	8,498	8,353	8,137	8,645	8,864	3,064	**180,294**
NdPr oxide	t	4,185	4,141	4,267	4,236	4,345	4,389	4,307	4,253	4,558	4,666	1,615	**93,307**
SEG/HRE oxide	t	587	582	602	594	607	613	599	584	625	642	222	**12,973**
TREO	t	12,991	12,842	13,178	13,093	13,426	13,500	13,259	12,974	13,828	14,172	4,900	**286,574**
P_2O_5	kt	73	74	74	76	74	72	74	74	75	75	26	**1,578**
MGA Phosphoric Acid	kt	136	137	137	141	137	133	138	138	138	138	48	**2,922**

Figure 15

Block Flow Diagram – Beneficiation, Phosphate Extraction and Phosphoric Acid Production

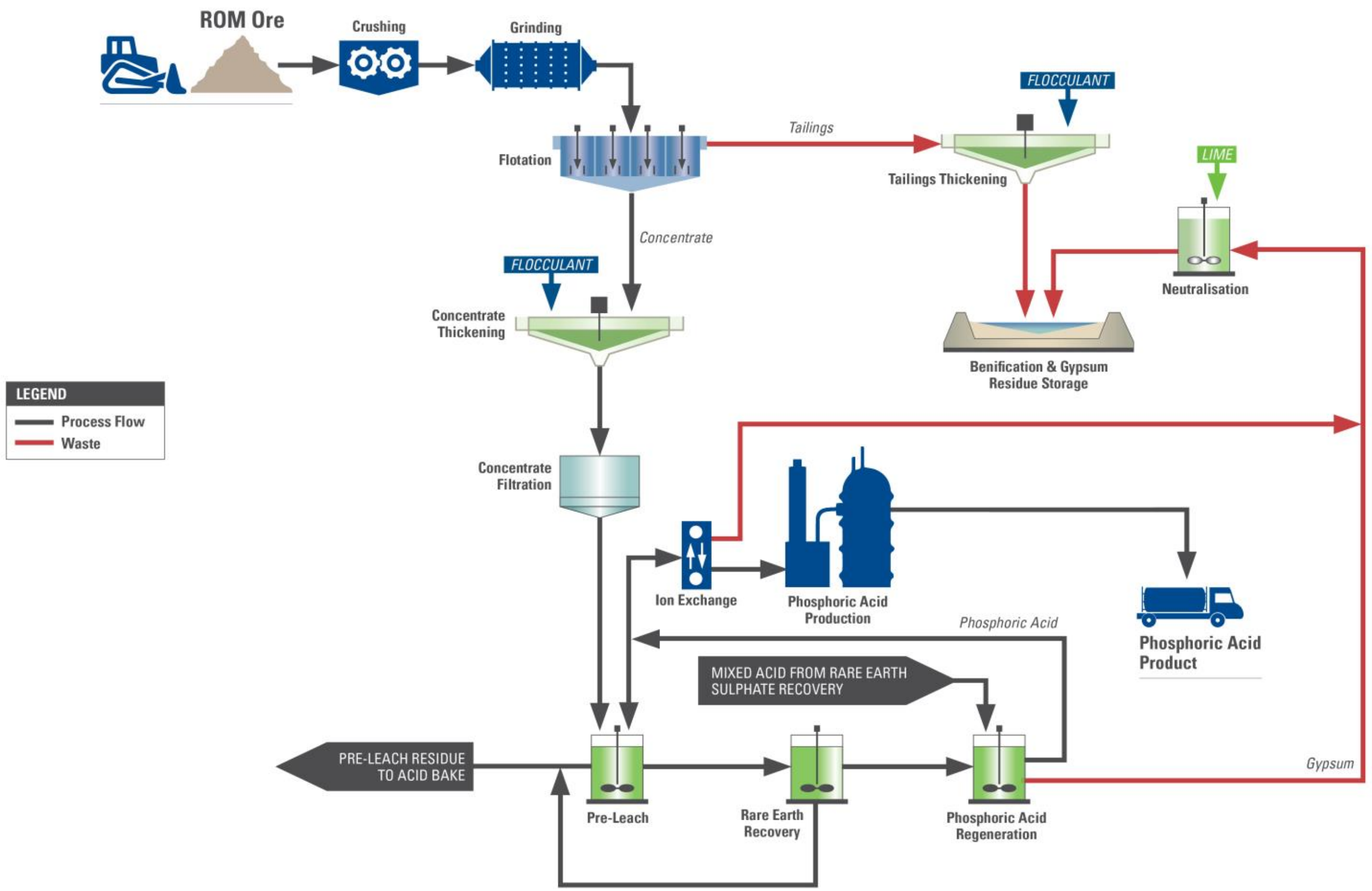


Figure 16

Block Flow Diagram – Rare Earth Extraction, Processing and Separation

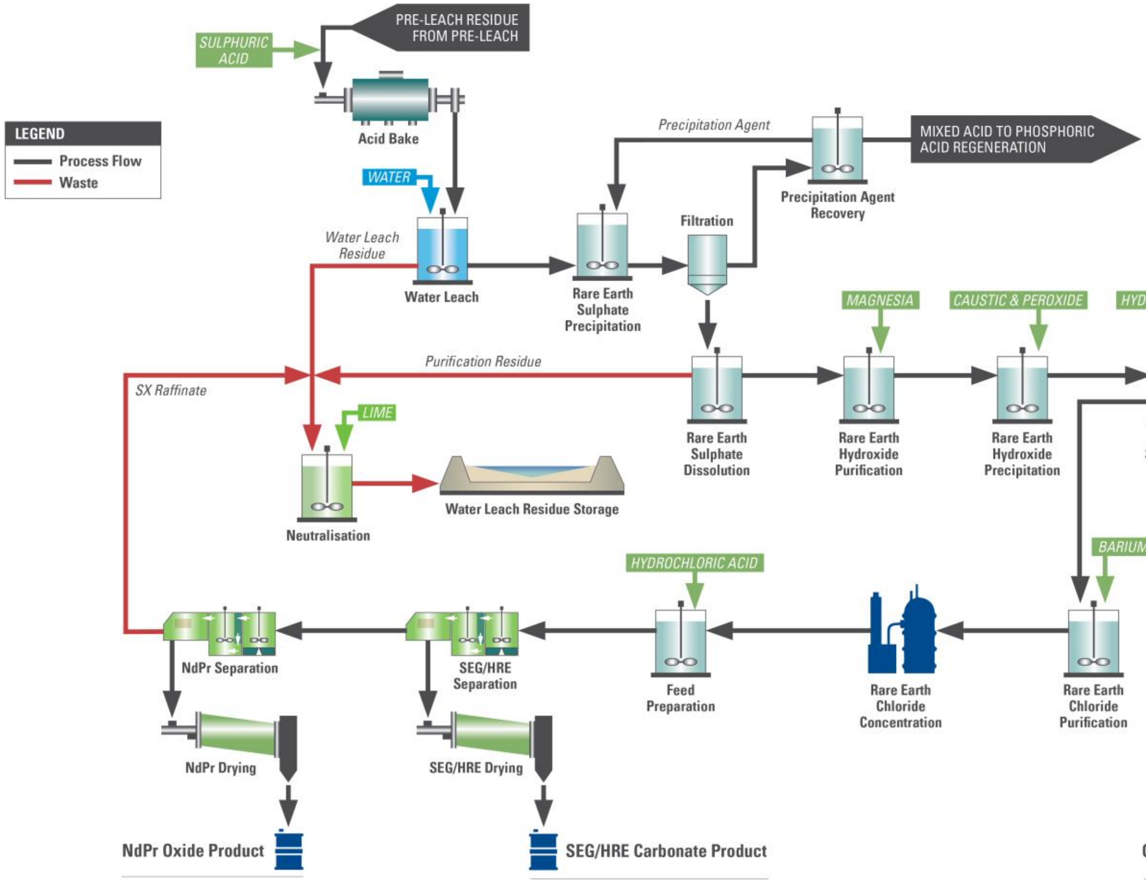
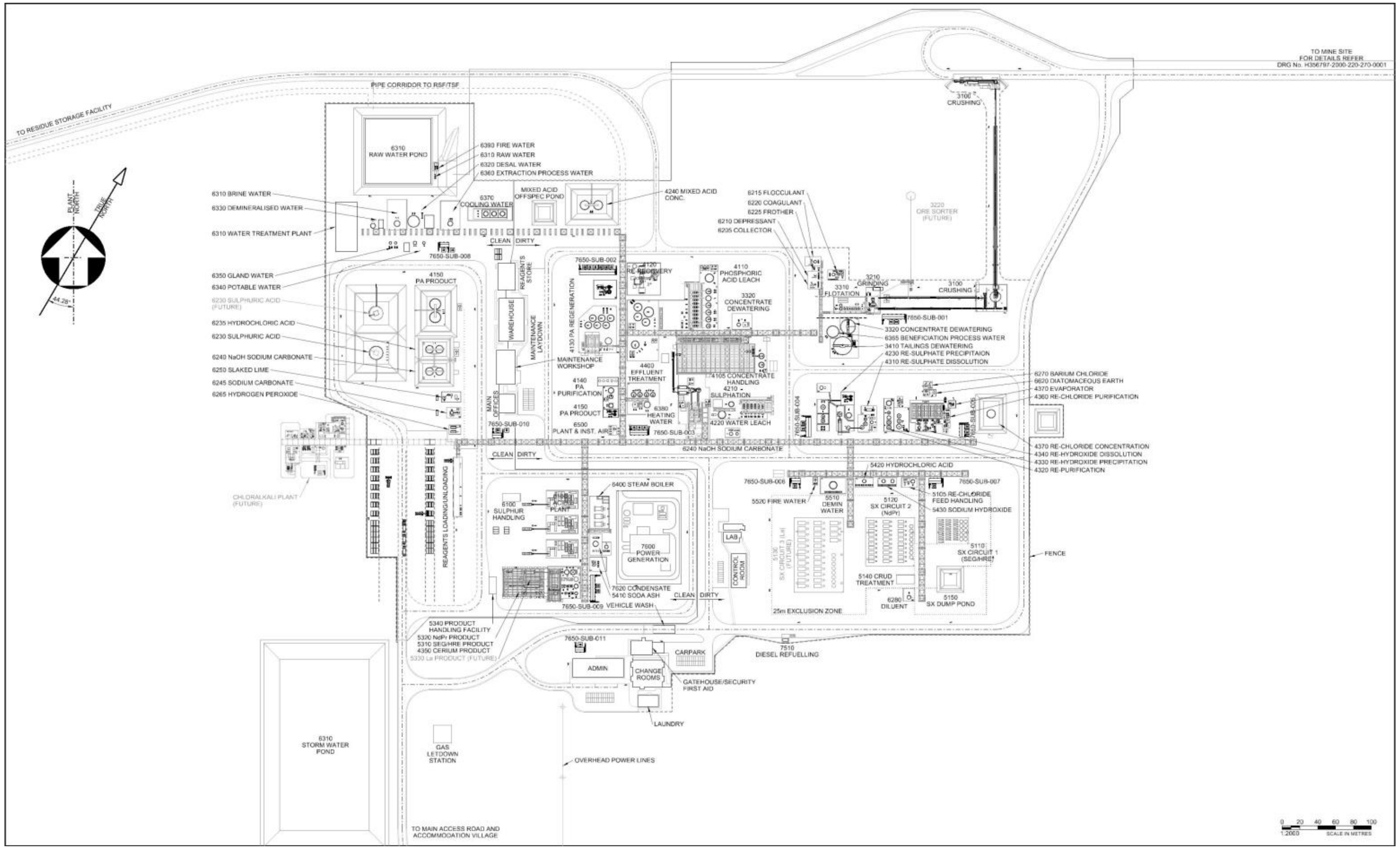


Figure 17

Overall Plant Layout



5.2.1 Beneficiation

The beneficiation facility will produce a concentrate to feed the extraction plant. The ROM ore will initially be crushed and ground in a single-stage semi-autogenous grinding (SAG) mill to produce a feed to flotation. Flotation will concentrate the phosphate minerals into a high phosphate concentrate containing the majority of the rare earths and tailings. Tailings will be pumped as a slurry to the RSF, whilst concentrate will be filtered and sent to the rare earth extraction area for further processing.

5.2.2 Phosphate Extraction

Phosphoric Acid Leach

The phosphoric acid pre-leach will leach the majority of the phosphate from the concentrate to leave a rare earth-rich residue. As the concentrate will consist primarily of phosphate minerals, MGA phosphoric acid can be produced as a by-product.

The process will begin with pre-leaching utilising a two-stage counter-current leach with phosphoric acid where most of the calcium and phosphate in the concentrate will be leached into solution leaving behind most of the rare earth minerals in the residue. Concentrate and Stage 2 centrate will be contacted in Stage 1 pre-leach tanks. Stage 2 pre-leach will involve the addition of fresh phosphoric acid from phosphoric acid regeneration to the Stage 1 pre-leach centrifuge cake. Solid liquid separation between Stage 1 and Stage 2 pre-leach stages is achieved using centrifuges, while counter-current centrifuge repulp washing will be applied to the Stage 2 centrifuge cake, with the final washed centrifuge cake repulped and pumped to the pre-leach residue filter. Pre-leach residue will be fed to the rare earth extraction area and Stage 1 centrate will be processed further in the rare earth recovery area to recover remaining rare earths and phosphoric acid.

Rare Earth Recovery

Rare earth recovery will ensure that REEs in solution following phosphate extraction are recovered prior to phosphoric acid regeneration to minimise rare earth loss to gypsum waste. Filtered solution from pre-leach will be combined with product from the rare earth recovery filter to aid in precipitation and later filtration. Combined feed at 65°C will feed to two rare earth recovery tanks in series with steam injection directly into the tanks to raise and maintain temperature and minimise scaling. The rare earth recovery tanks will operate at 100°C which is the temperature at which the REEs precipitate as rare earth phosphates. Discharge from rare earth recovery will feed to the rare earth recovery evaporator where temperature will be raised to 107°C, excess water will be removed and precipitation of REEs will be completed. Discharge from the rare earth recovery evaporator will be filtered with half the solids recycled as seed and the remaining solids repulped and transferred to the pre-leach residue filter feed tank to be blended in with pre-leach residue (PLR). Filtrate will be cooled and transferred to the phosphoric acid regeneration stage.

Phosphoric Acid Regeneration

Liquor from rare earth recovery will be treated to regenerate the phosphoric acid and precipitate gypsum. The rare earth recovery liquor will be fed to phosphoric acid regeneration, where sulphuric acid, mixed acid, phosphoric acid seed recycle and phosphoric acid sludge will also be added, with mixed acid as the primary reagent added to the tank. Temperature in regeneration will be maintained at 42°C by cooling heat exchangers. Gypsum slurry from regeneration will then be pumped to the phosphoric acid regeneration filters with one producing seed for recycle to the regeneration tanks and the other to produce waste gypsum. The seed will be repulped with desalinated water and pumped back to the seed recycle tank and the gypsum waste will be neutralised with lime and pumped to the RSF.

Filtrate from the phosphoric acid regeneration filters which contains calcium, phosphoric acid, thorium, and uranium will be recycled to pre-leach. Excess filtrate will be pumped to phosphoric acid purification for removal of uranium and thorium, and to adjust the composition of the phosphoric acid to meet MGA phosphoric acid specification.

Phosphoric Acid Purification

The removal of uranium and thorium from the liquor will be achieved by adsorption onto ion exchange (IX) resin. The effluent stream, which will contain the removed uranium and thorium, will be pumped to water leach neutralisation for precipitation and disposal to the RSF.

Sulphuric acid will then be added to the phosphoric acid solution, which will contain reduced levels of uranium and thorium, to adjust its composition prior to being pumped to the phosphoric acid evaporator to evaporate excess water and obtain the required P_2O_5 concentration of 54%, meeting the specification for MGA phosphoric acid.

5.2.3 Rare Earth Extraction

In rare earth extraction rare earth minerals will be converted from the phosphate form to the sulphate form, which makes them more amenable to recovery and separation from impurities. The PLR will be conveyed to two trains of sulphation equipment operating in parallel. Each train will consist of a sulphation dryer, pug mixer, acid bake and sulphation cooler. The dryers will dry the PLR at 120°C with moisture reduced to 0.5 %w/w. Dried PLR will then be acidified in the pug mixers by addition of 98% sulphuric acid. The acidified slurry will then discharge to the acid bake units which will be indirect, oil heated, paddle type heaters discharging material at 250°C. In the acid bake, rare earth phosphates will be converted to rare earth sulphates.

The material from the sulphation kilns will be directed to the sulphation coolers which will be indirect, water cooled, paddle type coolers. The material will be cooled to 50°C before discharging directly into the water leach circuit. The pug mixers and paddle dryers where reactions occur will generate gases, which will be extracted to a local wet scrubber.

Water Leach

The water leach circuit will have attritioning tanks, one for each sulphation train, in which the sulphated material will be repulped with chilled liquor from downstream processing. Rare earth sulphates will be leached into solution leaving any gangue insoluble species. The combined slurry will be pumped to a series of centrifuges for solid liquid separation and counter-current washing with downstream centrate and desalinated water. Final cake will be repulped and discharged through the water leach neutralisation circuit for disposal to the RSF, while the final centrate will be filtered and forwarded to the rare earth sulphate precipitation area.

Rare Earth Sulphate Precipitation

In the rare earth sulphate precipitation area, rare earth sulphates will be precipitated by mixing the solution with a precipitation agent in a series of tanks at 65˚C. The precipitation agent will suppress the solubility of rare earth sulphate materials over the other elements present in the liquor, which will result in rapid precipitation of rare earth sulphates, leaving acid and impurities in solution. Thorium phosphate will also co-precipitate with the rare earth sulphates. The slurry containing precipitation agent and precipitated rare earth sulphates will be filtered to remove rare earth sulphates. The filter cake will be washed before the cake will be fed to the rare earth sulphate dryer and then to rare earth sulphate purification. The filtrate containing the precipitation agent and mixed acid will be recycled to the recovery circuit for recovery and separation of the precipitation agent and mixed acid. The precipitation agent will be recycled for use in rare earth sulphate precipitation whilst mixed acid will be sent to storage tanks for use in phosphoric acid regeneration.

5.2.4 Rare Earth Processing

Rare earth processing will take the rare earth sulphate produced in rare earth sulphate precipitation and ultimately produce a cerium product and rare earth chloride feed to rare earth separation. Rare earth processing will consist of a number of unit operations starting with the purification of the rare earth sulphate. Sulphate purification will occur through a process of dissolution (insoluble thorium will be filtered and removed) followed by precipitation of impurity elements such as aluminium, iron, uranium, and residual thorium by pH adjustment using magnesia. The purified rare earth sulphate solution will then be converted to a rare earth hydroxide through precipitation with sodium hydroxide combined with oxidation using hydrogen peroxide. The rare earth hydroxide will then be selectively dissolved with hydrochloric acid to leave a cerium hydroxide product which will be filtered, dried and packaged. The rare earth chloride solution will then be purified to remove sulphate and radium, before concentration in the rare earth chloride evaporator for feed to the rare earth separation circuit.

5.2.5 Rare Earth Separation

In the rare earth separation area, the concentrated rare earth chloride solution will be treated via SX to produce two separate products: SEG/HRE carbonate and NdPr oxide. The option remains to add a third circuit for the recovery of La oxide, however this has not been included at this time due to the low value of the La oxide.

SEG/HRE carbonate will be generated from the loaded strip liquor of the first SX circuit and NdPr oxide from the loaded strip liquor of the second SX circuit. The rare earth products will be precipitated from the loaded strip liquors using sodium carbonate solution, filtered and then either dried (SEG/HRE carbonate) or calcined (NdPr oxide) before packaging.

Raffinate from the second SX circuit will be neutralised with the water leach residue before pumping to the RSF.

5.2.6 Effluent Treatment

The effluent treatment area will consist of two areas, gypsum neutralisation and water leach residue neutralisation. Gypsum residue will be neutralised with lime in two neutralisation tanks operating in series. The neutralised gypsum will be pumped to the RSF and combined with the beneficiation residue. Water leach residue, thorium residue, IX residue, SX raffinate, and various scrubber bleeds will be collected in two tanks operating in series and neutralised with lime. The neutralised residue will be pumped to the RSF.

5.2.7 Reagents and Services

The reagents area will be located separately to the remainder of the process plant to minimise interaction between delivery trucks and equipment/containers with process operations. The exception to this will be flammable reagents which will be delivered into the process plant and offloaded directly into storage tanks in the appropriate plant area.

Sulphuric acid used in the process will be generated from elemental sulphur in a sulphur burning acid plant and stored in a bulk tank for use. The sulphuric acid plant will also generate steam for process use from the waste heat. The majority of other reagents will be delivered either as a bulk liquid in specialised isotainers or as bulk solids ready for mixing on site. Bulk reagents will be unloaded into bulk storage tanks or silos for storage prior to use, with isotainers returned for re-loading at port. Minor reagents will be delivered in liquid intermediate bulk containers or bulk bags.

Following ramp-up and initial operations, a package chlor-alkali plant will be installed on site for the production of hydrochloric acid and sodium hydroxide for use in the process. The installation of the chlor-alkali plant is driven by a number of factors including the inclusion of the separation area of the process (which consumes significant quantities of hydrochloric acid and sodium hydroxide) at the Project site, as opposed to an offshore chemical precinct adjacent to an existing production facility, and marginally reducing production in the second half of the LOM.

Raw water will be supplied from borefields located 25 kilometres away and stored in a lined pond at the process plant. Raw water will be processed on site in two reverse osmosis plants for the production of desalinated water and demineralised water for use in the process. Desalinated water will also be sterilised for use as potable water.

6 INFRASTRUCTURE

6.1 Site Access and Roads

The proposed main site access road will be approximately 15 kilometres in length, with a large portion of its alignment following the alignments of existing station tracks. The full length of the proposed main site access road between the Stuart Highway and the process plant can be seen in Figure 18.

Figure 18
Site Roads

The road has been designed as an all-weather road and will have a two-coat bitumen sprayed seal surfacing for its entire length.

At the proposed main site access road intersection with the Stuart Highway, auxiliary lanes have been included in the design to accommodate accelerating and decelerating truck traffic travelling between the site and Alice Springs.

The proposed mine access road from the process plant area will be approximately 8.5 kilometres long and provide general access to the mine area and serve as the haul road for trucking of ore to the process plant. The road surface will be unsealed for its entire length and will require regular maintenance to maintain efficient transport of personnel and ore.

6.2 Water Supply

The water supply investigation has focussed on the predicted groundwater extraction for the Project based on a total extraction of 3.4 GL per annum for 20 (and 40) years.

The southern basins borefield is focused on the Reaphook palaeochannel aquifer (Figure 19) which has been delineated using a combination of drilling and geophysical interpretation. The hydraulic properties of the aquifer have been interpreted using a combination of airlift yields, pumping tests, grain-size analyses and steady-state numerical modelling. Given the arid climate, it is considered that recharge is likely to be significantly lower than the volume of extraction. Despite low recharge volumes, calculations at a range of specific yields demonstrate the groundwater in storage is significantly larger than the volume of planned extraction.

The design of the five borefields (Figure 20) allows for nine new production bores to pump at an average of 12 L/s each. The borefields will be in locations with proven high yields, other than a central borefield. Within each borefield, individual bores are designed to be a nominal 100 metres apart. Each borefield will consist of the following infrastructure:

- Three production bores fitted out with bore hole pumps, headworks and buried delivery pipelines.
- Collection tank for water from the three bores.
- Pumps to transfer the water from the collection tank to the central borefield collection tank via buried delivery pipelines.
- Genset and diesel storage tank.
- Control system including instrumentation and microwave communications back to the process plant.
- Fenced compound.

The central borefield will be fitted with a larger collection tank and will pump directly from the borefield area to the process plant via a buried pipeline installed predominately along the alignment of the AGP.

The borefield has been designed to concentrate the drawdown on the easternmost portion of the Reaphook palaeochannel and extract additional groundwater resource from the feeder channels to the east. This design also allows extraction within a relatively close proximity to the Nolans site whilst minimising the impact on areas to the west and south thought to have the potential to contain groundwater dependent ecosystems (GDEs). Other design scenarios, with a greater spread of borefields further to the west, decrease the maximum drawdown at the pumping bore locations but result in significantly more interaction with areas that are likely to contain GDEs.

Numerical modelling has been undertaken to display a range of groundwater drawdown impacts in the borefield area, and the prediction considered most likely is presented in Figure 20. In all scenarios, the outcomes for the aquifer are relatively similar, in that drawdown is significant in the epicentre of the borefield and takes decades to hundreds of years after closure to recover. This drawdown is not anticipated to impact any current known beneficial uses. In the scenarios where the specific yield is modelled at the unlikely low value of 0.01, drawdown impacts on an area considered the most likely to contain potential GDEs, in the vicinity of Day Creek and the Reaphook Hills. Numerical modelling has demonstrated how such drawdown could be managed and mitigated locally, through targeted re-injection in the event of such low specific yields being observed once pumping commences.

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Figure 19

Reaphook Palaeochannel Aquifer

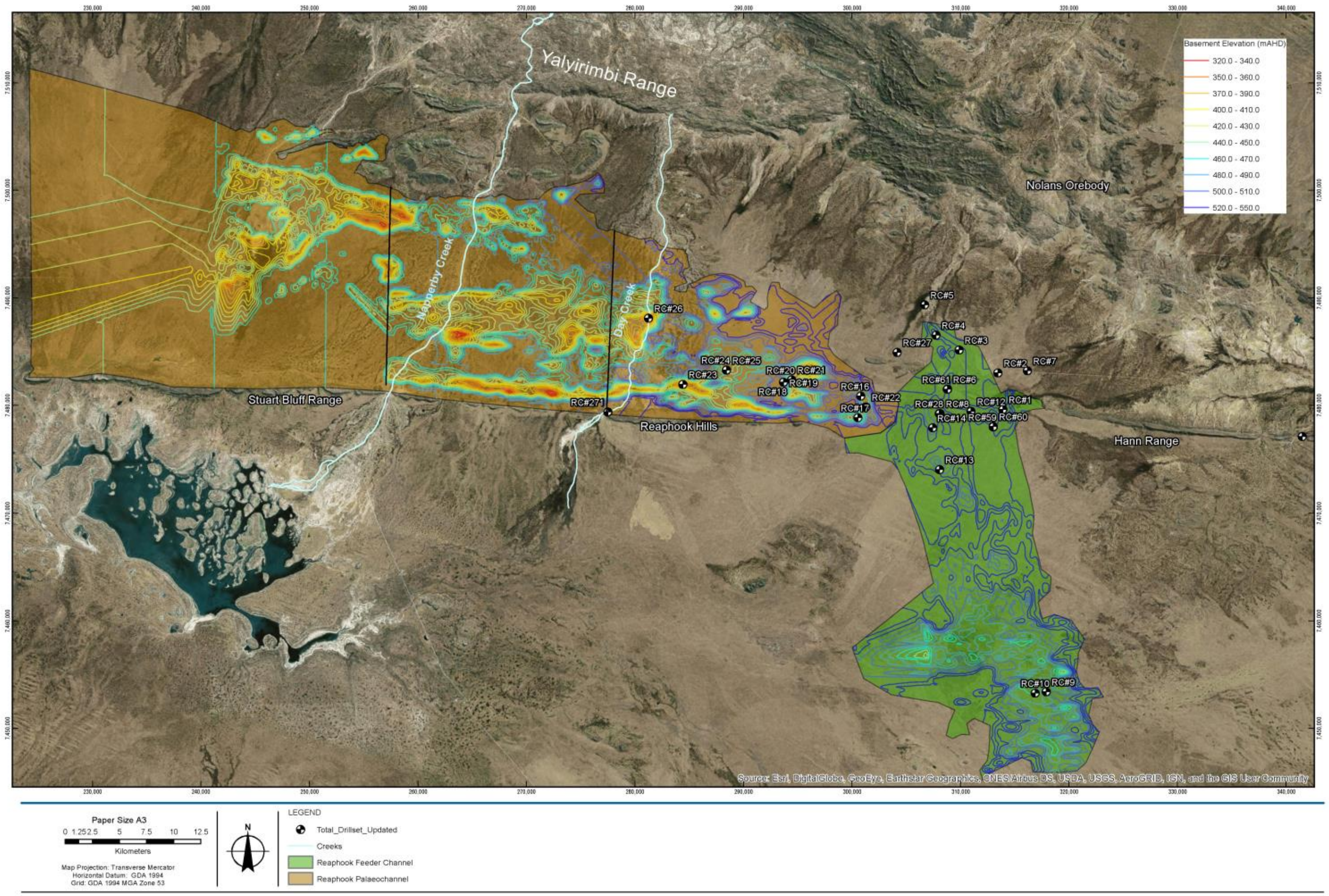
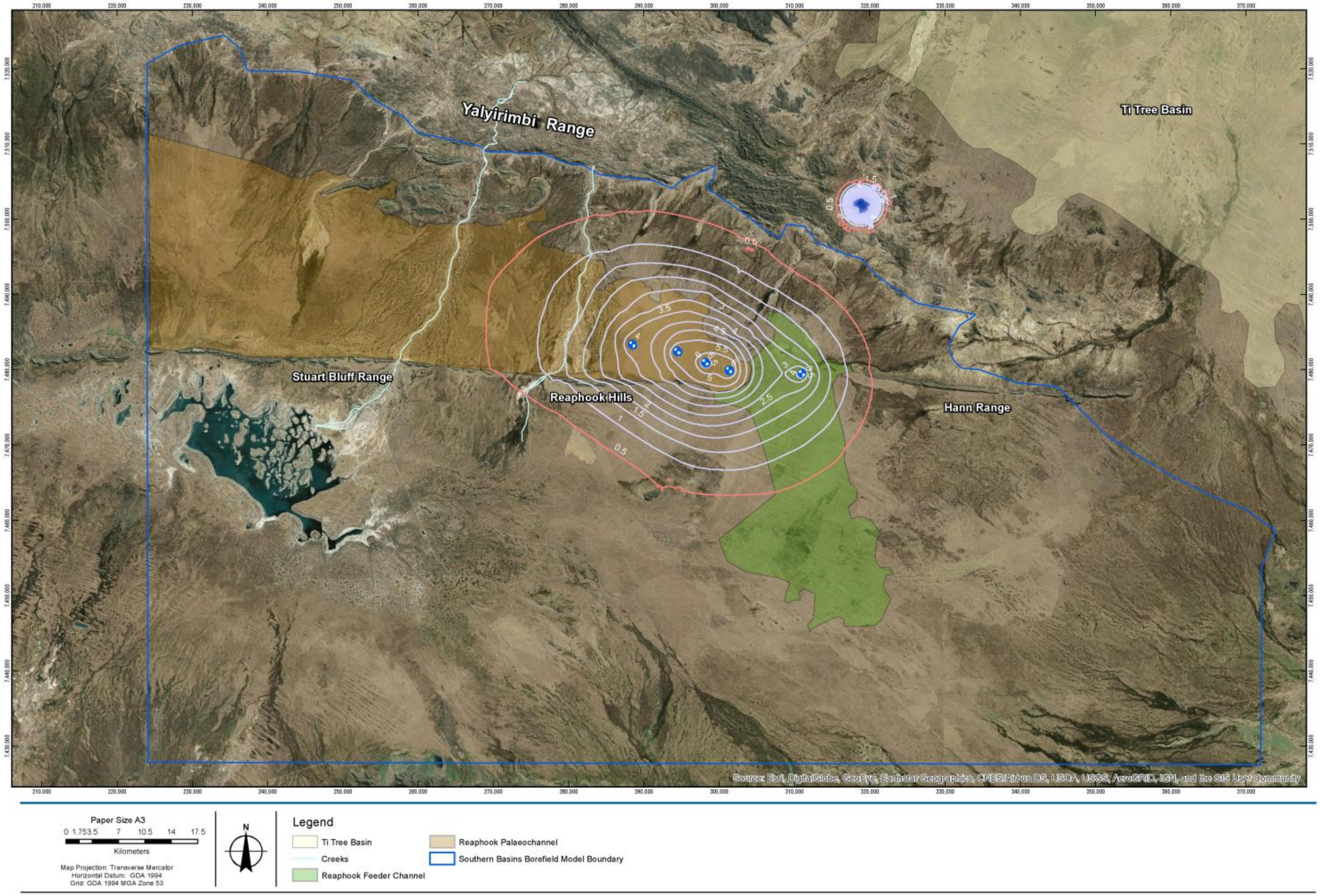


Figure 20

Predictive Closure Drawdowns with Aquifer



A significant groundwater monitoring program has been designed to provide ongoing information on aquifer properties, groundwater modelling validation and drawdown impact. Additional modelling following receipt of long-term groundwater level monitoring data is recommended to address key gaps in the hydrogeological data including recharge and storage estimations, as well as the presence or extent of confining conditions. The current model is considered a Class 1 model and the steps required to achieve a Class 2 groundwater model have been documented as part of these works.

Mining of the Nolans pit will completely extract the small confined aquifer (both the rock and water) associated with the orebody. Drawdown is highly unlikely to be measurable in the Ti Tree Basin (Figure 20) as the pit is highly likely to be isolated from the basin by a basement groundwater divide, much higher in the landscape and hydrogeological regime than the basin standing water level.

6.3 Energy Supply and Power

Due to the close proximity to the AGP and the superior efficiency of gas-fired power generation when compared to diesel, natural gas has been chosen as the primary energy source for the Project. Discussions with natural gas producers have indicated abundant supply of gas for the Project with transport capacity existing in the AGP.

A build, own, operate (BOO) arrangement has been chosen for the main power plant providing power for the process plant and the accommodation village. The mine site and borefields will be serviced by diesel generating sets due to their distance from the power plant and small electrical loads.

Steam required for the process plant will be supplied by utilising and depressurising the high-pressure waste steam from the sulphuric acid plant, backed up by gas fired boilers for acid plant outages.

A summary of the Project's main energy requirements is shown in Table 23.

Table 23
Project Energy Requirements – excluding mine site and borefields

Item	Units	No Chlor-Alkali Plant	With Chlor-Alkali Plant
Site power demand (inc. acid plant) – gas fired	MW	34.0	38.4
Emergency power demand – diesel fired	MW	1.6	1.6
Overall steam (inc. acid plant)	t/h	51	51

The anticipated annual natural gas requirement for the Project is shown in Table 24.

Table 24
Project Natural Gas Requirements

Item	Units	No Chlor-Alkali Plant	With Chlor-Alkali Plant
Site power demand (inc. acid plant) – gas fired	PJ/annum	2.45	2.80
Natural gas for steam generation	PJ/annum	Stand-by Only	
Natural gas for process use	PJ/annum	0.43	0.43
Total natural gas consumption	**PJ/annum**	**2.88**	**3.23**

6.4 Residue Storage

All processing waste streams generated within the process plant will be pumped as a slurry to the RSF, a purpose built, long-term, earth fill, lined containment facility. The RSF footprint has been designed for the entire LOM and will be a permanent facility that will be closed and rehabilitated on site without the need for any further residue handling.

The RSF will be constructed in a series of stages over the LOM. Each stage will comprise of two individual cells which are constructed and operating concurrently, one cell to store a blend of the beneficiation and gypsum residue streams and the second cell the water leach residue.

In total, six cells (three beneficiation/gypsum residue cells and three water leach residue cells) will be constructed to store the LOM residue production of 20.6 Mt. Each cell will operate for approximately seven to nine years and will then be decommissioned and capped in preparation for rehabilitation, which will occur concurrently with ongoing operations for the first four cells (the final two immediately post closure). Subsequent cells will be constructed immediately adjacent to the initial structure. In addition to the volume occupied by the residue, each cell can contain the rainfall runoff due to extreme short duration storms and/or prolonged wet periods. A general arrangement of the final RSF design is provided in Figure 21.

6.4.1 Facility Hazard Rating

In accordance with Australian National Committee on Large Dams (ANCOLD) guidelines, design criteria have been based on a hazard rating of "High C" for the facility.

Geochemical testing of representative samples has indicated that the residues have an elevated level of a number of environmentally significant elements that will require control during operations and post closure. The RSF will be classed as a radioactive waste disposal facility for "Very Low Level Waste" in accordance with the relevant Australian regulations, similar to numerous other facilities in operation in Australia. The main design features associated with this classification are seepage control measures, dust control and closure capping requirements.

Figure 21
LOM RSF Layout.

6.4.2 Site Geotechnical Investigation

A site specific geotechnical investigation for the RSF location was completed in 2018 with the following main points noted:

- Boreholes and test pits indicate that the near surface clayey sands (and some calcrete) is continuous across the RSF and overlies.
- Fresh rock is present at between four metres and seven metres depth.
- Laboratory testing has confirmed that clayey sands prevalent across the entire RSF basin area exhibit low permeability and will provide sufficient seepage control within the beneficiation/gypsum residue cells and act as a suitable secondary soil liner in the water leach residue cells.

6.4.3 Facility Layout

The facility will be built in two-yearly stages from local borrow materials, sourced within the footprint of future cells and ultimately, a rock outcrop located on the northern extent of the facility.

The beneficiation/gypsum residue cells will comprise a reworked soil lined basin with a full piped underdrainage network to provide seepage control and reduce seepage losses.

The embankments will have a low permeability soil upstream fill zone and will be built using modified centreline construction techniques. A continuous cut-off trench will be constructed beneath the entire length of the embankment and will be excavated into a competent foundation layer to provide further near surface seepage control.

The water leach residue cells will comprise of two basin liners, a primary high-density polyethylene (HDPE) geomembrane overlying a secondary engineered soil liner with a full piped underdrainage network, in addition to a leak collection and recovery system. The embankments will have a low permeable upstream fill zone as well as a HDPE geomembrane liner. A cut-off trench will be located beneath the entire length of the embankment and will be excavated into a competent foundation layer to provide further near surface seepage control. To facilitate full and continuous installation of the geomembrane and engineered soil liners, the embankments will be constructed using full downstream construction techniques.

Earthworks will be supervised by a qualified engineer on behalf of the Engineer of Record with full quality assurance and quality control (QAQC) testing during construction. Records will be compiled in a formal construction report for sign off at the end of each construction phase.

6.4.4 Operation

Process residue will be pumped to the RSF as a slurry and deposited from multiple spigots along the embankment, using the sub-aerial deposition method. Solids will settle out and excess water will be recovered and returned to the process plant for reuse via decant towers located in each cell.

Both cells are expected to operate water negative for the majority of average years, with a supernatant pond generally at the minimum operable size throughout the period and water return only likely during rainfall events.

6.4.5 Closure

Each cell will operate for seven to nine years before deposition shifts to newly built cells. On decommissioning, each cell will be capped with an impermeable soil layer to isolate the deposited residue and reduce rainfall infiltration. Long-term stable water management structures will be constructed across the facility and rockfill placed to control erosion in critical area. The facility will then be revegetated.

6.5 Buildings

Industry typical transportable buildings have been included in the design for light or personnel use. Transportable buildings include:

- Security gatehouse, including emergency response and first aid.
- Process plant administration building.
- Process plant control room.
- Changing rooms and associated laundry.
- Process plant laboratory.
- Process plant maintenance offices.
- Mine administration building (provided by the mining contractor).
- Mine crib room and ablutions (provided by the mining contractor).

Industrial buildings have been included in the design for heavy use applications such as workshops and storage sheds. Industrial buildings include:

- Process plant maintenance workshop.
- Process plant warehouse.
- Process plant dry reagent store.
- Mine heavy and light vehicle maintenance workshops (provided by the mining contractor).
- Mine general store (provided by the mining contractor).
- Mine core sample storage shed.
- Ammonium nitrate storage shed.

6.6 Accommodation Village

The accommodation village will be located approximately 5 kilometres from the process plant, to be accessed along the main site access road. For operations, the village will consist of 300 rooms operating on a non-motelling arrangement. For construction, the village will have a peak occupancy of 650 on a motelling arrangement.

Central facilities and permanent accommodation units will be purchased, while the additional accommodation units required during the construction phase will be leased.

In addition to the accommodation provided at the village, approximately 50 accommodation units will be available at the nearby Aileron Roadhouse (approximately 15 kilometres from the Project village) to provide contingency peak accommodation and also act as a fly-camp to facilitate early works construction.

6.7 Other

Vehicle washdowns located at key locations around the site will provide for the effective removal of mud and dust and ensure vehicle cleanliness for maintenance, but also aid in site radiation management. Vehicle washdowns will be incorporated at the process plant main gate, mine access road (mine end) and mine heavy vehicle workshop (heavy vehicles).

Diesel fuel storage will be installed at the mine area, process plant, power station and each of the borefields to support the operations with supply of diesel by road tanker from Alice Springs.

7 LOGISTICS

Qube has performed a desktop logistics study to ascertain the most efficient and economical supply chain for the Project. Based on the results of this study, the Project will import reagents and consumables through both Darwin Port or Port Adelaide as described in Table 25.

Table 25
Key Reagent Importing Locations

Reagent	Location	Shipment type	Transfer
Sulphur	Darwin Port	Bulk shipment	Ex-vessel
Sulphuric acid	Darwin Port	Bulk Shipment	Ex-tank
Hydrochloric acid	Darwin Port	Isotainers	Ex-port
Quicklime	Darwin Port	Bulk shipment	Ex-works
Precipitation agent	Darwin Port	Isotainers	Ex-port
Sodium silicate	Darwin Port	Isotainers	Ex-port
Sodium hydroxide	Port Adelaide	Bulk shipment	Ex-tank
Sodium carbonate	Port Adelaide	Bulk shipment	Ex-works
Hydrogen peroxide	Port Adelaide	Bulk shipment	Ex-works

The Project will export all products through Darwin Port in the shipment types described in Table 26.

Table 26
Key Product Exporting Locations

Product	Location	Shipment type
NdPr oxide	Darwin Port	Containerised drums
MGA phosphoric acid	Darwin Port	Bulk shipment
Cerium hydroxide	Darwin Port	Containerised bulk bags
SEG/HRE carbonate	Darwin Port	Containerised drums

7.1 Darwin

Darwin Port operates commercial wharf facilities at East Arm Wharf and is capable of accommodating container ships, dry bulk imports and bulk liquid vessels. Containers will be offloaded to a container yard and bulk commodities will be stored in dedicated facilities before being containerised for transport to site.

Containers will be trucked to a dedicated laydown yard where the logistics contractor will schedule their inclusion on one of the five available rail services to Alice Springs. In Alice Springs the containers will be removed from the rail service and transferred to triple road trains for road transportation to site. Containers requiring transportation to Darwin will complete the reverse route.

Most reagents and consumables will be imported through Darwin Port. The major categories of shipment types and methods of handling are:

- Bulk sulphur – Sulphur will be imported to Darwin Port and stevedoring will be undertaken by the Project's logistics contractor. An existing storage shed at the port will be extended and configured to store 20,000 tonnes of sulphur. Lidded, end tip shipping containers will be loaded with sulphur by the logistics contractor.
- Bulk liquid – Sulphuric acid may be imported through Darwin Port's bulk liquid terminal and stored in an existing 25,000 tonne tank. The logistics contractor will be responsible for loading acid isotainers and delivering by road to the laydown yard.
- Containerised imports – Reagents imported to Darwin in shipping containers will be transferred to the Port's container yard. The logistics contractor will then transfer by road to the laydown yard. Any amalgamation of containers will be the responsibility of the logistics contractor to achieve efficient transportation of reagents and consumables.

7.1.1 Products

Packaged and containerised rare earth products will be transported to Darwin Port for exporting utilising the same logistics path that the reagents and consumables follow. Empty shipping containers will be returned to site for refilling.

MGA phosphoric acid will be loaded into dedicated isotainers or backloaded into sulphuric isotainers on site. These isotainers will be transported to the bulk liquid storage facility at Darwin Port where the acid will be transferred into a new dedicated 20,000 tonne tank. Empty isotainers will either be utilised for transporting sulphuric acid to site or will return empty for reloading with MGA phosphoric acid product.

7.2 Adelaide

Port Adelaide handles a diverse range of inbound cargoes and surrounding infrastructure supports the importation of liquid sodium hydroxide and hydrogen peroxide amongst other bulk and containerised commodities.

The Project will not be responsible for the importation of any bulk commodities through Port Adelaide, instead reagents will be purchased ex-tank from existing suppliers. The logistics contractor will be responsible for loading isotainers from suppliers' facilities and transporting by road to a dedicated laydown yard. Containers will be then be transferred to the Adelaide Rail Terminal siding for inclusion on one of the five available train services to Alice Springs. Empty isotainers will be returned via the same route for reloading.

7.3 Alice Springs

Freight will be removed from train services in Alice Springs and temporarily stored at the Alice Springs rail siding. Triple road trains will operate 24 hours per day from Alice Springs to site to complete the logistics route.

At site the road trains will be unloaded by the logistics contractor and all handling of containers and isotainers on site will be performed by the logistics contractor.

8 OPERATIONS

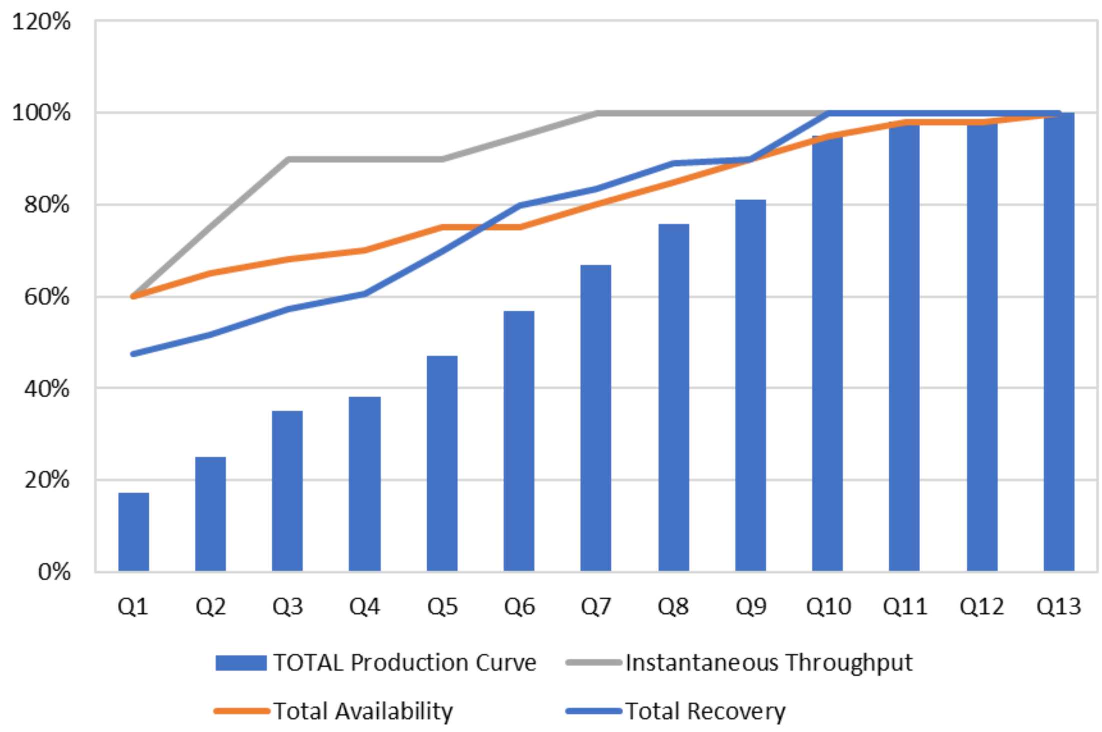
8.1 Production Ramp-Up

The Project's total production ramp-up schedule has been developed in quarterly segments by the multiplication of three ramp-up components:

- Instantaneous throughput ramp-up.
- Plant availability ramp-up schedules for the beneficiation, extraction and separation plants.
- Total rare earth recovery ramp-up.

The methodology adopted was a combination of literature reviews, predominantly McNulty[1] and experience of similar complex hydrometallurgical operations. The Project's ramp-up period is expected to have a maximum duration of three years. The combination of the factors described above produce the overall production ramp-up curve for the Project. Figure 22 shows the production ramp-up at each quarter of the maximum ramp-up period.

Figure 22
Production Ramp-up Curve



[1] McNulty, T.P., 1998, Developing Innovative Technology, Mining Engineering October 1998, pp 50-55

8.2 Operating Philosophy

8.2.1 Radiation management

Naturally occurring uranium and thorium are present with the REEs in the ore. Throughout the process plant the radioactivity level will vary depending on the stage of the process until finally, REEs will be extracted, and radioactive material will be disposed in the RSF.

It is a requirement of the radiation management plan that work areas be designated as clean and dirty (based on the potential for exposure to radioactive materials) and that appropriate hygiene procedures are followed to limit exposure to radioactive substances.

8.2.2 Contract Operations

The following major contract operations will be utilised for the operation of the Project:

- Contract mining operations, including drill and blast activities, mining activities, ROM pad operation and haulage of ore to the process plant.
- Logistics operations for transport of goods to and from site, including port operations, intermodal operations, rail operations, road transport and loading and unloading at site.
- Camp operations, including messing, camp cleaning, cleaning of site offices, laundry operations and staff transport to and from Alice Springs.
- Laboratory services, including provision of laboratory equipment, consumables, systems and staff.
- Shutdown maintenance.

All other activities will be carried out by directly employed Arafura staff who will be supported by expert consultants and minor contract services.

8.3 Manning

Required personnel will be split amongst the following departments to give a total of 278 employees and contractors for the Project, excluding the off-site logistics services. Project personnel requirement by department are provided in Table 27.

Table 27
Project Personnel

Administration & Commercial	21
Mining (peak)	113
Processing, including laboratory, power station & site logistics	71
Maintenance	33
Health, Safety, Environment & Community	15
Camp	25
Total	**278**

9 HUMAN RESOURCES

Following the development of the operational organisation structure and identification of the optimal workforce numbers, an analysis of labour rates was undertaken. The following was determined when identifying labour costs:

- Identification of rosters: A review of potential rosters was undertaken, including an analysis of rosters in similar operations and locations. The intended roster for each position and location was identified. This included identification of rosters as fly-in/fly-out (FIFO) rosters or Alice Springs residential rosters.
- Development of a salary classification structure: A structure was developed for all positions that would assist with the identification of salaries and other benefits.
- Review of current market salaries and general market conditions: Current market salaries were identified via knowledge of the industry and recruitment activity occurring in the industry. Arafura will aim for the mid-point of the market for most positions, with some flexibility for leadership and essential specialist positions. The market was also reviewed, and potential labour shortage areas were identified and considered in determining salary and conditions.
- Identification of minimum salaries under the Mining Industry Award: All positions covered by the Mining Industry Award were reviewed to ensure that there was an adequate buffer between the award rates and proposed salaries.
- Identification of non-salary benefits: Benefits were identified for employees who will reside in Alice Springs to ensure attraction and retention of employees. These benefits include local living allowances, relocation allowances, and annual travel allowances.
- Identification of travel and accommodation costs (site-based accommodation).
- All additional on costs including payroll tax and workers compensation.

In addition, the potential start-up costs and ongoing costs associated with recruiting the operations workforce were identified. These included the costs associated with:

- Resources for sourcing, targeting and recruiting labour.
- Pre-employment medicals and assessments.
- Assistance of agencies for some roles.
- Targeted recruitment activity including recruitment fairs in Alice Springs, Darwin and Adelaide.

9.1 Indigenous Employment

Arafura's ongoing commitment is to engage proactively with the Alice Springs community and with indigenous communities surrounding and close to the Project. As part of this Arafura has commenced the development of an indigenous engagement and employment strategy to identify opportunities for indigenous employment and local business development. The aim is to maximise initial indigenous opportunities and to grow these opportunities over the life of the Project.

10 IMPLEMENTATION

10.1 Contracting Plan

A contracting strategy was developed utilising a combination of a phased engineering, procurement and construction (EPC), owner 'direct managed' and engineering, procurement and construction management (EPCM) contract packages. Within this contracting strategy the entire scope has been divided into various contract packages, which have been allocated to four main management centres: Mining, Process Plant, Non-Process Infrastructure and Direct Managed.

The allocation of capital costs between the four management centres is shown in Table 28.

Table 28
Allocation of Capital Costs

Mining	A$M	35 – 40
Process Plant	A$M	650 – 700
NPI	A$M	170 – 180
Owner's Team & Direct Managed	A$M	75 – 80

The contracting strategy seeks to reduce project risk by implementing a phased EPC approach in which suitable contractors will be selected to participate in a competition phase for the process plant which is the largest and highest risk part of the project scope. This single process plant contract package represents approximately 70% of the capital value and is considered the best contract form to manage the execution risk to a level that is acceptable to Arafura and potential project financiers.

The phased EPC approach will commence with an early contractor involvement (ECI) stage that will develop the technical and commercial aspects of the Project such that a target cost estimate for the process plant, together with a pain/gain share mechanism, can be agreed upon with the contractor. In the second EPC development stage, if awarded, the process plant contractor will continue engineering and procurement development to a level of completion where a lump sum EPC contract price can be agreed, having regard for the target price estimate set in the ECI stage. The EPC execution stage will commence when the total funding package has been secured by Arafura. At the completion of the process plant construction and commissioning, any incentive amount for achieving the target price is calculated and awarded to the contractor.

This staged approach allows project technical risk to be shared in a collaborative manner between Arafura and the contractor by avoiding early setting of a lump sum price, to meet the funding schedule, before engineering and procurement has been substantially advanced. Accordingly, the phased contract development is tied closely to project financing and allows the staged commitment while funding proceeds. This allows engineering development to proceed in parallel with funding activities and maintains schedule momentum.

Since the process plant contractor will only deliver the process plant, a second NPI contractor will be appointed to implement the major non-process infrastructure packages using an EPCM contracting strategy. Using this approach, there will only be two main design and construction management parties for the Project, which will reduce interface issues.

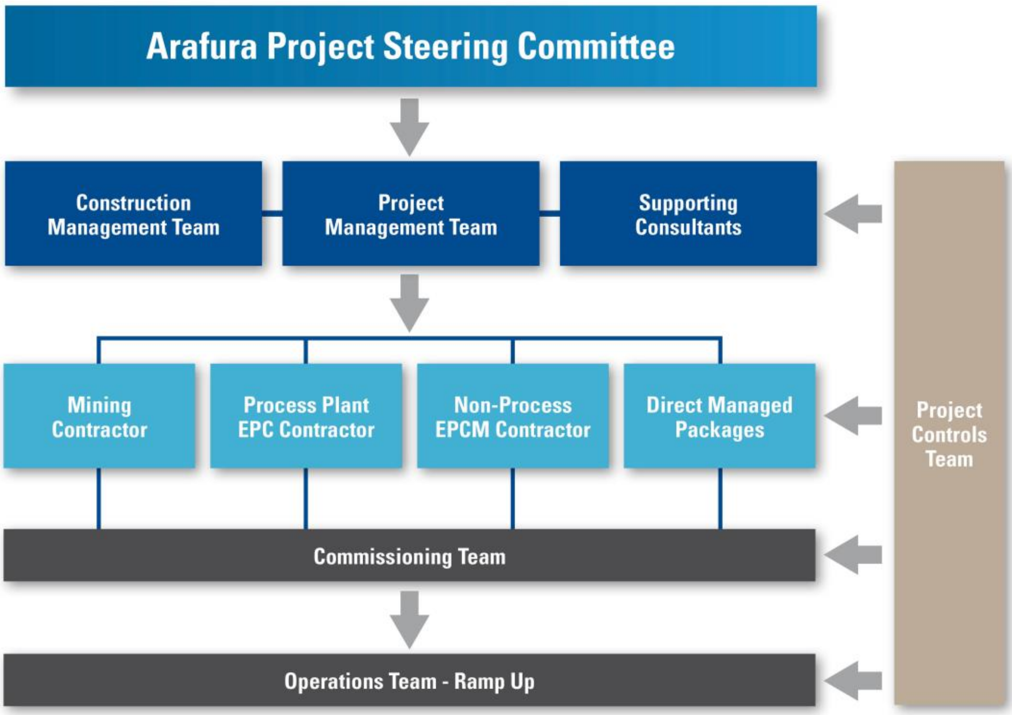
10.2 Project Organisation

An owner's team will be established as an integrated management team with a project management consultant that broadly comprises of a project management team and a construction management team. In addition to Arafura personnel, staff from the project management consultant will be integrated into the project management team and will provide mature project management and control systems required to ensure robust project control. The project management team will be based in the Perth Project office under the direction of the General Manager - Projects.

The construction management team will be based at the site for the duration of the Project. The construction management team will provide the superintendence for the process plant contractor, non-process infrastructure contractor and the smaller direct-managed packages, to achieve orderly and time effective site activities and drive the construction management philosophy in terms of health and safety, quality and productivity.

A high-level view of the Project structure is presented in Figure 23.

Figure 23
Project Organisational Structure



10.3 Operational Readiness and Pre-Production

In the three to six months prior to the commencement of commissioning activities, the Arafura operations team will be recruited and mobilised to site. They will participate closely in the construction verification and pre-commissioning process, which precedes the start of process plant dry and wet commissioning.

Operations and maintenance readiness systems will be developed in parallel with the design, construction and commissioning of the facilities. This will include the development of plant operating procedures, general plant procedures, configuration of the enterprise resource planning (ERP) systems, planned maintenance work schedules and the maintenance procurement systems.

Initially the site will have limited facilities, until the operations facilities in the plant area have been commissioned. Therefore, the operational readiness activities will initially be located off-site where the focus will be on system development and procurement activities. Once major off-site tasks have been completed, site facilities are available, and the commissioning timeframe is firm, the operations personnel will be mobilised to site.

10.4 Project Schedule

The Project implementation schedule developed as part of the DFS shows that the Project can be developed, from date of Project commitment (the date at which the process plant ECI stage commences) to start of ore commissioning, within a 30-month timeframe. The date of Project commitment is driven by securing enough funding to commence with the ECI stage of the process plant development.

Key project milestones in the schedule are shown in Table 29.

Table 29
Key Project Milestones

Project Commitment	Month 0
Process plant Stage 1 – Early Contractor involvement commencement	Month 1
Process plant Target Cost Estimate agreed	Month 6
Process Plant Stage 2 - EPC Development commencement	Month 7
Long Lead Equipment orders	Month 8 – 12
Process Plant Stage 3 – EPC Execution contract award	Month 13
Early works construction commences	Month 7
Process plant site construction commences	Month 13
Pre-production mining commences	Month 22
Process plant commissioning – first ore feed to plant	Month 30

It is planned that an early works stage will precede the main process plant construction by approximately 6 months. This stage of works will prepare the site facilities required to support the main project construction stage, and include the following:

- Water supply borefield and pipelines.
- Main access road up to the process plant.
- Accommodation village and utilities.
- Communications tower and backhaul systems.
- Process plant bulk earthworks and site utilities.

- Process plant administration buildings (to be used as owner's team offices during construction).

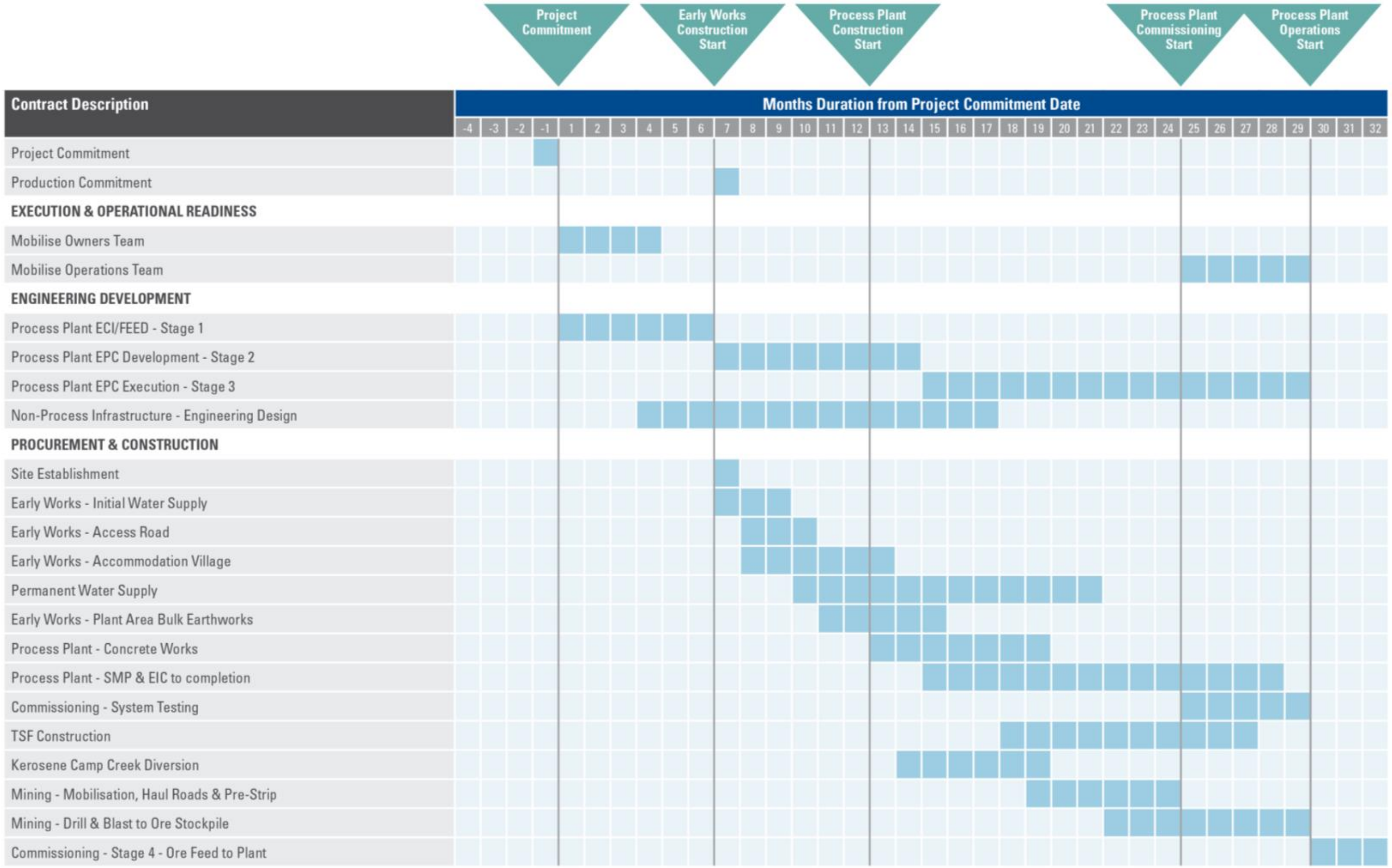
Long-lead equipment items have been identified in the DFS and these will be procured early in the ECI and EPC development stages in order to maintain the project implementation schedule. Commencement of process plant construction will be driven by engineering development and certified vendor data from the long-lead equipment suppliers. It is planned that the first concrete pour for the process plant will occur in 12 months following Project commitment and signals the start of the 18-month construction period, until the first ore feed occurs 30 months after Project commitment.

The Project's critical path is driven by the design and early procurement of the strip and evaporation equipment packages, closely followed by the sulphuric acid plant and kiln procurement packages.

Figure 24 presents a summary project implementation schedule.

Figure 24

Project Implementation Schedule



11 ENVIRONMENTAL, SOCIAL, APPROVALS AND LAND ACCESS

11.1 Environmental Approvals and Risk Assessment

In December 2014 Arafura lodged a variation notification with the Northern Territory Environment Protection Authority (NT EPA) in accordance with the Section 14A 'Procedure where proposed action altered' under the Northern Territory *Environmental Assessment Act* (EA Act) varying a previously lodged Notice of Intent. Pursuant to Section 14A of the *Environmental Assessment Administrative Procedures*, the NT EPA considered the alteration and determined that an EIS was necessary to assess the Project.

In February 2015, Arafura 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 was required at a federal level. Two triggers for assessment under Commonwealth legislation were identified as having 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 and Biodiversity Conservation Act 1999* (EPBC Act):

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

Subsequently, the Project was assessed under a bilateral agreement between the Australian and Northern Territory governments made under Section 45 of the EPBC Act.

In May 2016 Arafura lodged the EIS for the Project. The document was assessed and went on public display for comment for an eight-week period. Following receipt of comments from regulators, non-government organisations (NGOs) and other stakeholders a detailed supplemental EIS document was prepared and lodged in October 2017. This document was then assessed, and the NT EPA recommended the Project for approval in December 2017 with 16 recommended approval conditions.

The NT EPA assessment report and recommendations were then forwarded to the Commonwealth for its consideration, subsequently in May 2018 the Commonwealth approved the Project with conditions aligned with the NT EPA.

As anticipated the recommended approval conditions have a strong focus on the management and sustainability of ground and surface water, management of Project waste streams, the Project's and region's biodiversity and the management of radiation. All recommended conditions are considered appropriate and achievable with no issues likely in complying with the requirements of the approvals.

With the configuration changes that have resulted from studies undertaken as part of the DFS, Arafura is preparing a further Section 14A variation document under the EA Act for the NT EPA's consideration. Arafura has met with NT EPA assessment officers and discussed these changes and additions. Following that discussion, it is considered that none of the changes materially alter or add to any of the identified Project risks or impacts and as a consequence it is not anticipated that any additional approval conditions will be added to the existing approval once this variation is assessed and considered.

Arafura has also engaged with officials from the Commonwealth Department of the Environment and Energy (DoEE) to discuss these planned configuration changes and their potential impact on the EPBC approval. DoEE has subsequently confirmed that the changes do not present additional material risk to the approval and consequently no further action is required.

11.1.1 Risk Assessment

The Project's EIS was completed with a specific emphasis on the identification, analysis and mitigation of potential environmental and Project risks. The risk assessment approach provided a framework for identifying components of the Project that had the potential for greater environmental risk and highlighted Project specific control measures to minimise or mitigate the likelihood and consequence of these identified risks occurring. The impact pathways and proposed controls were then used to inform the proposed environmental management framework for the Project, including an environmental management plan and associated sub plans.

A rigorous risk assessment process was undertaken, which presented separately both environmental and socio-economic risks. The risk registers contain details of impact pathways, consequences, planned controls inherent in the Project description, an initial risk assessment, additional controls, and a 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.

Details of the risk profile for the Project are presented in the EIS (available at www.arultd.com) in Chapter 5 and Appendix F and G. With changes in planned Project configuration, from the EIS project configuration, the risk profile, pathways, consequences or planned controls have been reviewed to determine if there have been any alterations or amendments. As a result of this review process no changes to the risk matrices were required and all proposed controls have been deemed adequate.

11.2 Native Title and Heritage

Over the Project area there are three registered native title claimant groups. All three groups cover the mine site, the process plant area and borefield area on Aileron Station. One group covers the western extent of the planned borefield area which is located on Napperby Station.

The native title rights and interests co-exist with the pastoral interests under the perpetual pastoral leases on which the Project will be built. Arafura has an obligation to pay compensation to native title holders for any interference with their native title rights and interests. Arafura is seeking to settle such compensation through the process of negotiation via the Central Land Council (CLC) as part of the Nolans Project (ML 26659) Native Title Agreement (with accompanying Section 31 Agreement) and Nolans Project (Southern Titles) Indigenous Land Use Agreement (ILUA).

It is anticipated that the agreement or agreements will be in place during the first half of 2019.

If such agreements cannot be reached and Arafura proceeds to obtain the Project's MLs through alternative future act processes, such that compensation is not agreed up front, then the native title holders may claim compensation under the *Native Title Act* using the same compensation principles as determined by the Northern Territory *Mineral Titles Act* (MTA) such that Arafura is obliged to pay compensation to native title holders for damage to the land, and any improvements to the land caused by the activities conducted under the mineral titles and any loss suffered as a result of that damage (for example, loss suffered as a result of being deprived of the use of the land). If agreement cannot be reached on compensation the native title holders may claim for such compensation either through the Northern Territory Civil and Administrative Tribunal (NTCAT) or the Federal Court.

Aboriginal and historic (non-Aboriginal) cultural heritage values of the Project area have been documented, and the potential impacts on Aboriginal and historic heritage arising from Project activities, assessed. A review of the environmental, ethnographic and archaeological context of the Project area was undertaken to identify the potential for any unknown objects and/or places of significance. Three cultural heritage surveys have been completed on the Project since 2006 with the most recent completed in 2015. 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. Details of surveys and planned management strategies can be found in the EIS (Chapter 16 and Appendices U and X).

Three places within 10 kilometres of the study area are declared heritage places:

- Aileron homestead.
- Ryan Well historical reserve.
- Annas Reservoir conservation reserve.

None of these heritage places will be impacted by the Project.

There are a number of archaeological sites in the Project area. 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 sacred trees. Overall, 67 Aboriginal archaeological sites (including 34 isolated artefacts) have been recorded during archaeological surveys. A high proportion of the archaeological sites are associated with specific features such as outcrops of gneiss domes and platforms, at the base of the steep ridges and over the lower gneiss foothills.

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 Arafura 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.

11.3 Permitting

There are a number of tasks to be completed with respect to permitting for the Project both prior to and following construction. These tasks include:

- Finalisation of a native title agreement or ILUA. The final form of this agreement will be determined during the negotiations with the CLC who represent the native title holders. This agreement once executed will require subsequent approval by the Commonwealth Minister for Indigenous Affairs. Once approved, this agreement will then enable the Northern Territory Minister for Primary Industry and Resources (delegated to the Department of Primary Industry and Resources (DPIR)) to grant the primary and ancillary MLs over the Project area, securing the Project's mineral resource and associated plant and infrastructure areas.

- Authorisation from DPIR under the *Mining Management Act* is required to enable the commencement of construction and operations on the granted MLs. A prerequisite to this authorisation is the lodgement of a compliant Mining Management Plan (MMP). The MMP must detail all planned activities on the Project and provide a range of management plans which outline how the various environmental safety and community aspects of the Project will be managed during construction and early operations. The document must include reference to the approval conditions of both the Northern Territory and Commonwealth governments showing how the approval conditions are being implemented and actioned. The MMP is currently in preparation and will be lodged with DPIR in early 2019 for review in readiness for a subsequent authorisation in mid-2019 once is the MLs are granted.

- A water extraction licence under the Northern Territory *Water Act* for the proposed raw water supply borefield must be granted to allow the abstraction of groundwater for construction and operations. A licence application has been prepared and has been reviewed by the Northern Territory Department of Environment and Natural Resources (Water Division). To date, the licence application has been assessed as compliant, however, with the subsequent changes to project water demand the application will be amended to reflect this demand. It is anticipated that the application will begin formal administrative assessment in February to March 2019.

- Application will be made for heritage clearances to remove identified artefacts once Project design is completed and accurate assessment of the planned location of infrastructure against the information obtained from the various site cultural and heritage surveys is possible. It is likely that there will be a number of cultural artefacts which will require removal from several locations within the MLs prior to construction. Removal of artefacts in the Northern Territory requires a permit from the Northern Territory Department of Tourism and Culture (Heritage Branch) before such an action can be taken. Removal will also be carried out in consultation with the CLC and the native title holders.

- The Project will require registration as a "radiation place" under the Northern Territory Department of Health as a consequence of the Project's concentrations of uranium and thorium. This is a straightforward administrative licencing process that will be completed once design is finalised and prior to operations commencing at the Project site.

11.4 Land Access

The Project is located predominately on Aileron Station with a small part of the borefield infrastructure located on the adjacent Napperby Station. Both of these stations are perpetual pastoral leases under the Northern Territory *Pastoral Land Act*. Arafura has rights of access and use of its existing Project tenure under the provisions of the MTA.

Upon the grant of the MLs and related tenure, Arafura will have rights of access and use of its Project area, the right to occupy the Project MLs and the exclusive right to carry out authorised mining activities on the Project MLs.

At this time a claim for compensation by the pastoral lease holders can be made and Arafura is required to make genuine efforts to reach agreement on compensation with the pastoral lease holders. Pursuant to the MTA the compensation is to be paid for damage to the land and any improvements to the land caused by the activities conducted under the mineral titles, and any loss suffered as a result of that damage (for example, loss suffered as a result of being deprived of the use of the land). The pastoral lease holders are not entitled to compensation in relation to minerals known or thought to be on or under the land (*i.e.* preventing any royalty payments as compensation). In the event that compensation cannot be agreed between the parties then the pastoral lease holders may refer the matter to the NTCAT to determine the compensation in accordance with the MTA.

12 CAPITAL COST ESTIMATE

12.1 Estimating Method

Capital costs for Project have been developed based on the designs developed and described in this report. In addition, the costs have been developed in line with the implementation methodology and contracting strategy presented in Section 10.1. The estimate has generally been compiled based on the mechanical equipment list, specifications and material take offs (MTOs) produced for the DFS, and include:

- Purchase and installation of permanent plant, equipment and materials.
- Construction labour.
- Construction plant and equipment.
- Contractors' preliminaries, overheads and profit.

The capital cost estimate for the Project has been developed to be generally consistent with the requirements of an AACE Class 3 estimate and similar projects carried out in Australia.

12.2 Basis of Estimate

The capital cost estimate was compiled on the following basis:

- Bulk materials and equipment quantities have been developed based on the engineering completed during this study.
- Major equipment supply has been included based on budget quotes sourced during the study.
- Bulk materials supply and installation pricing has been compiled based on a combination of first principles estimating and recent historical data from the region and validated by budget quotes.
- Construction labour rates have been based on current labour agreements assuming a 100% FIFO workforce.
- The estimate has been compiled on the following execution basis:
  - Combination of EPCM and large EPC package execution as described in Section 10.1.
  - Asian supply and fabrication of structural steel and platework.
  - Traditional field installation with equipment and bulk materials brought to the site in the largest possible items able to be transported via standard gauge road transport.
- Project indirect costs have generally been included based on detailed estimates and aligned with the execution plan and schedule.
- Contingency has been included at mean confidence based on the quantitative risk analysis (QRA).

- Sulphuric acid plant Modules 2 and 3 are excluded (deferred capital), however preliminary works such as earthworks, concrete and tie-in points are included.

- Chlor-alkali plant is excluded (deferred capital).

12.3 Work Breakdown Structure

The work breakdown structure (WBS) corresponds to the physical plant areas with the addition of indirect and owner's costs. A high-level summary of the WBS is provided in Table 30.

Table 30
Work Breakdown Structure

2000	Mining
3000	Beneficiation Plant
4000	Extraction Plant
5000	Separation Plant
6000	Reagents and Services
7000	Non-process Infrastructure
8000	Indirect Costs
9000	Owner's Costs

12.4 Estimate Currency and Base Date

The capital cost estimate is expressed in Australian dollars (A$). The estimate base date is the 4th Quarter 2018.

The exchange rates in Table 31 have been used in the compilation of the capital estimate. All costs were carried through to the financial model in the native currency such that foreign exchange modelling can be carried out in the financial model.

Table 31
Foreign Exchange Rates

Currency	Exchange Rate	% of Capital Cost
United States Dollar	0.720	10.0%
Euro	0.595	12.6%
Australian Dollar	1.000	77.4%

12.5 Quantity Development

Quantities for the estimate were developed using the following basis:

- Pre-production mining quantities, which are included in the mining schedule, were developed based on the detailed mine design and scheduling.
- RSF and surface water management structure quantities were developed based on the layout drawings and preliminary designs developed for the DFS and also include detailed engineering and construction supervision by the engineer.
- The earthworks design is based on the site layout drawing, from which a 3D design was developed for the quantities.
- Concrete and foundation designs were developed based on a 150 kPa ground bearing pressure. Quantities were then developed based on the 3D model and preliminary structural engineering for major facilities. The sizing of major equipment foundation elements has been based on preliminary equipment sizes from consultant's in-house historical data.
- The structural layouts were based on the 3D model with guidance from the mechanical and process disciplines with primary and secondary steel sized based on the Project design criteria and preliminary engineering based on the available vendor information.
- MTOs for process piping were extracted from the 3D model for greater than DN90 for HDPE, and greater than DN80 for other material types. For the outstanding piping not included in the 3D model, estimated lengths were based on the plant layout. The balance of small-bore piping, valving and special piping items were included as a factored allowance. Valve MTOs were generated from the piping and instrumentation diagrams (P&IDs).
- Maximum demand and switch gear sizing by substation was calculated from the load list developed from the mechanical equipment list. From this maximum demand and switchgear sizing, transformer and switchgear ratings were determined. Quantities for electrical bulk materials (cables, cable ladder/conduit, trenching, lighting and local control stations) have been included based on take-off using the electrical load list, single line diagrams, high voltage (HV) cable schedule and plant layout.
- Control and instrumentation quantities were calculated and based on the engineering completed during the study, primarily the mechanical equipment list, load list and preliminary P&IDs.

12.6 Pricing Basis

Pricing for the various aspects of the estimate were based on the following:

- Pricing for the mining aspects of the capital costs (mobilisation, site preparation and pre-production mining) was based on mining contractor budget quotations, as outlined in Section 3.6.
- Equipment supply costs have generally been included based on budget quotes sourced during the study. Budget price enquiries were issued to at least three vendors where possible. Budget quotations were reviewed for technical compliance, with the lowest technically compliant offer being included in the estimate in most instances.

- Allowances have been included for vendor representatives, and were considered necessary, either based on the vendor's recommendation or as a 2% allowance of supply costs.

- Freight has been included based on a combination of quotes from equipment vendors, where provided, or as an estimate for packages where a freight price was not received.

- Equipment installation costs have been included based on man-hours per item of equipment and multiplied by the project labour rate, and productivity with man-hours are based on either vendor information received with quotes (particularly for larger packages) or standard man-hours developed based on previously completed similar projects.

- Mobile equipment has been priced based on an assessment of requirements and historical costs.

- Earthworks rates have been built up from a combination of first principles estimating, based on equipment rates, labour rates and productivity, and historical data. Diesel is included at $0.96 per litre based on quoted rates for supply from Alice Springs.

- The cost of concrete supply, reinforcing and formwork have been included based on recent data from the region, validated with contractor quotes received based on a preliminary enquiry for the Project.

- Structural steel cost including shop drawings/detailing, supply, fabrication, surface treatment, delivery to site and installation were included based on historical data for Asian supply and fabrication. Minor supply of fabricated steel from local fabricators was allowed for in the QRA process.

- Piping supply and installation rates have been calculated from first principles based on labour productivity for each piping type and complexity along with historical data for minor piping and consumables.

- Budget quotations for supply of substations, motor control centres and transformers were received based on preliminary specifications, datasheets and typical designs. These quotations were combined with historical data for minor equipment and electrical bulk commodities.

- Budget quotations for the control system, operator consoles, and communications infrastructure were received based on preliminary specifications and control input/output requirements. These budget quotations were combined with historical pricing data for the balance of equipment including field instrumentation and control valves.

- Buildings have been included based on the developed requirements, plant layout and individual building layouts prepared during the study which were used as the basis for budget quotations.

- For the accommodation village, an option to purchase a second-hand village to accommodate operations personnel, supplemented by rental of accommodation units for the construction phase was offered and selected for the Project.

12.7 Growth and Wastage Allowances

Equipment cost growth has been included at 5% for general equipment, 3% for buildings and 10% for the SX package, totalling to an equipment growth allowance of A$17.3M.

Quantity growth allowances have been included in some areas of the MTOs where uncertainty exists around the design or level of engineering definition.

The growth allowances were determined based on the level of engineering definition and are summarised in Table 32.

Table 32
Quantity Growth

Description	Growth %	Growth A$M	Weighted Growth %
Earthworks	10% to 20%	3.9	7%
Concrete	10%	5.8	9%
Structural Steel	10%	4.7	10%
Architectural	5%	0.1	0%
Piping	15%	7.6	11%
Mechanical Platework	20%	1.3	3%
Mechanical Equipment	0%	0.0	0%
Electrical Bulks	15% to 25%	6.8	15%
Electrical Equipment	10%	1.3	3%
Instrumentation	10%	0.6	5%
Total		**32.1**	

** "Weighted Growth %" reflects the growth percentage after being applied to selected items within each discipline. For example, the nominated growth allowance for a discipline might be 20% across 20 estimate items, but only a selected number of items were deemed to require this growth allowance. Thus, the weighted average is calculated to be lower.*

A wastage allowance was added where appropriate to bulk materials for material that will be purchased and not installed (*e.g.* over-pour on concrete, piping and cable off-cuts). This allowance is 5% for the majority of bulk materials with 10% included for blinding and 2.5% included for electrical bulks.

12.8 Installation Costs

Direct field labour is the skilled and unskilled labour required to install the permanent plant, equipment and bulk materials at the Project site. Direct field installation man-hours were developed using first principles estimates based on standard unit man-hours for each commodity applied to the quantity.

Man-hours shown in the estimate only include direct labour, up to and including leading hands. Contractor supervision and administration, engineering and owner's team labour is excluded, and is included as a separate cost, without man-hours. The site manning estimate for construction does, however, include allowances for these supervisory roles.

Installation costs included in the estimate cover commissioning up to and including mechanical completion.

The labour rates used in the estimate have been based on current labour agreements. Calculated labour rates are based on the following:

- 100% FIFO employment.
- 4 week on / 1 week off roster.
- 13-day fortnight (*i.e.* each second Sunday is not worked).
- 12-hour days.

The labour rate is composed of direct labour and contractors' indirect costs. Table 33 provides the unweighted labour rate used in the estimate.

Table 33
Labour Rate

Description	A$/hr
Base Labour	67
Contractor Distributables	77
Construction Plant	17
Average unweighted all-in labour rate (excl. earthworks)	**161**

The rates for earthworks have been separately built up for each quantity type from first principles and vary significantly based on the construction plant which is used for the task.

The base labour rates reflect actual working hours per week, consisting of normal time, and penalty rates for all hours in excess of normal time. Contractor distributables have been calculated based on a factored cost of the direct man-hours including mobilisation, demobilisation, site facilities, consumables, safety and quality, financing costs, management and supervision, head office support, general construction equipment and profit.

Adjustments to estimated base man-hours are made using a global productivity factor to reflect the specific conditions at the Project site. Key drivers for the productivity calculation include:

- Inclement weather.
- Fatigue and lost time associated with travelling employees and work rosters.
- Standard of supervision
- Safety culture requirements.
- Job site and task inductions.
- Re-work.

For the Project the labour productivity has been determined to be 1.30.

12.8.1 Construction Rates Validation

During the DFS three contractors were requested to provide budget quotations for a selection of key activities based on a preliminary scope of work. The quotations were used to validate the rates developed for the estimate to ensure the estimate was aligned with current market rates for the region. In addition, the contractors provided input on execution methodology, schedule, work rosters, risks and opportunities.

Table 34 summarises the comparison between the estimated costs and the contractor quotations for the specified scope of work.

Table 34
Construction Contractor Comparison to Hatch Estimate

Description	DFS Estimate	Contractor A		Contractor B		Contractor C	
Steel	44.8	52.1	116%	39.4	88%	53.5	119%
Concrete	41.1	42.3	103%	29.5	72%	57.3	139%
Pipe	10.6	13.4	126%	15.4	145%	21.4	202%
Cable	20.7	16.1	78%	8.3	40%	-	-
Earthworks	12.3	13.9	113%	13.3	108%	-	-
Total A$M	**129.5**	**137.8**	**106%**	**105.9**	**82%**	**-**	**-**

The comparison shows a variance at the individual rate and discipline level, however the total cost is within the budget quotes provided. Based on this alignment no changes were made to the rates, or man-hours utilised in the estimate. It should be noted that Contractor A did not provide a detailed breakdown of the electrical rates and only provided a suggested percentage saving from the estimate rates.

12.9 Owner's Costs

Owner's costs includes all costs incurred by Arafura prior to commencement of production. The following areas form the scope of the owner's cost estimate:

- Owner's project management team labour cost during EPC and commissioning.
- Owner's team expenses and indirect costs.
- Mining costs, including detailed mine design, carried out by consultants, and owner's mining equipment costs.
- Environmental consulting for construction clearances, auditing and operational planning reviews.
- Project insurances.
- Operational readiness (maintenance planning).

- Pre-production labour costs (progressive mobilisation of production labour to be ready for plant acceptance and commencement of operations).

The owner's cost estimate is presented in Table 35.

Table 35
Owner's Costs

Description	A$'000
Owner's Project Team Labour & On-Costs	17,407
Owner's Team Expenses	2,353
Mining Costs	426
Environmental	125
Project Insurances	3,881
Operational Readiness	1,624
Pre-production Labour	10,896
Total	**36,712**

The owner's cost estimate was developed as a first principles estimate. All significant and measurable items are itemised and supported by quotations. Smaller items are built up from a cost database.

12.10 First Fills

First fills have been included based on an assessment of the initial requirements. Unit rates have been based on reagent costs from the operating cost estimate other than for IX resin where a lower bulk rate was provided by the supplier. The total first fill cost is A$10.2 M, with the major components being the IX resin, SX organic, sulphuric acid, phosphoric acid, sodium hydroxide and hydrochloric acid.

12.11 Spares

Spares have been included in the estimate based on a percentage allowance of equipment costs. The costs and basis are provided in Table 36.

Table 36
Spares

Description	Cost A$M	Basis
Maintenance Spares	2.6	1% of mech. equipment supply cost
Insurance Spares	7.8	3% of mech. equipment supply cost
Commissioning Spares	2.6	1% of mech. equipment supply cost
Process Control Spares	0.2	From vendor quotation
Total	**13.2**	

12.12 Indirect Costs

Indirect costs have been included for:

- Project management and detailed engineering. Labour rates have been included based on anticipated categories of each role and assumes detailed engineering where appropriate will be completed from high value or low-cost centres. The estimate of man-hours has been prepared based on the engineering deliverables required, anticipated manning, project schedule and roles required.
- Construction management is included in the "all-in" labour rate allowance for contractor distributables.
- Temporary construction facilities. Temporary construction facilities for the integrated contractor and owner's team on site has been included based on the identified facilities required to operate the site and includes the establishment, operations and removal at Project completion. This includes site offices, laydown pads, warehousing, security and minor plant and equipment for site maintenance and miscellaneous tasks.
- Travel and accommodation. Travel and accommodation has been calculated from first principles based on 100% FIFO workforce, quoted average flight costs from commercial airlines to Alice Springs, 4 week on / 1 week off roster and quotations for the messing and operation of the accommodation village.

12.13 Accuracy Range and Contingency Analysis

In accordance with industry best practice a QRA was completed to determine the capital cost and schedule risk profiles for the Project.

The QRA assessed the level of Project schedule and cost performance variability and risk to establish an appropriate level of contingency to be applied to the current schedule and cost estimates for this stage of the Project development.

Contingency is a provision for known project costs that will occur but cannot be defined in sufficient detail for estimating purposes due to the lack of complete, accurate and detailed information, as well as limited engineering which has been performed to date. The addition of contingency is required to determine the most likely cost of the Project. The project contingency does not cover scope changes, project exclusions or changes to the proposed execution strategy.

The schedule risk analysis results indicated a mean contingency of 14% of the Project duration and an accuracy for the 80% confidence interval of -7% to +7%.

A detailed Monte Carlo analysis was completed based on the outcomes of the QRA. Contingency has been included in the estimate at the mean, which equates to 12.6% of the base estimate. The estimate accuracy determined following the QRA was assessed at –13.2% to +16.1% at 80% confidence.

12.14 Deferred Capital

Deferred capital has been estimated for the following:

- Modules 2 and 3 of the sulphuric acid plant, which is anticipated to commence in year one of operations and be delivered by the main Project contractor.
- Chlor-alkali plant, which be delivered as a separate project later in the Project LOM.

12.15 Presentation of Estimate

12.15.1 Cost by WBS

Table 37 summarises the capital cost estimate for the overall project by WBS.

Table 37
Overall Project Capital Cost Estimate Summary by Area

Description	A$M
Mining Infrastructure	20.9
Pre-Production Mining	19.1
Beneficiation Plant	42.3
Extraction Plant	284.4
Separation Plant	48.1
Reagents & Services	147.9
Non-Process Infrastructure	173.2
Total Direct Cost	**736.0**
Temporary Construction Facilities	15.0
Travel & Accommodation	11.3
Detailed Engineering & PCM	64.9
Spares & First Fills	23.3
Mobile Fleet	5.6
Owner's Costs	36.7
Import duties	2.8
Total Indirect Cost	**159.6**
Contingency	110.4
Escalation	Excl.
Total	**1,006.1**

12.15.2 Cost by Discipline

Table 38 summarises the capital cost estimate for the overall project by discipline.

Table 38
Overall Project Capital Cost Estimate Summary by Discipline

Description	**A$M**
Pre-Production Mining	19.1
Earthworks	66.7
Concrete	68.9
Electrical Bulks	52.7
Electrical Equipment	38.3
Instrumentation	14.8
Mechanical Equipment	264.6
Mechanical Platework	42.8
Piping	77.1
Structural Steel	47.4
Architectural	43.6
Total Direct Cost	**736.0**
Indirect Costs	159.6
Contingency	110.4
Escalation	Excl.
Total	**1,006.1**

12.15.3 Quantity and Cost Maturity

Quantities for directs cost were categorised by the level of engineering completed in support of the estimate. Quantity maturity is summarised in Table 39.

Table 39
Quantity Maturity

Description	**% of direct cost**
Feasibility Design	69%
Preliminary Design	25%
General Arrangements & Historical data	5%
Allowances	1%
Direct Costs	**100%**

As with quantities all unit rates have been categorised by basis. Cost maturity is summarised in Table 40.

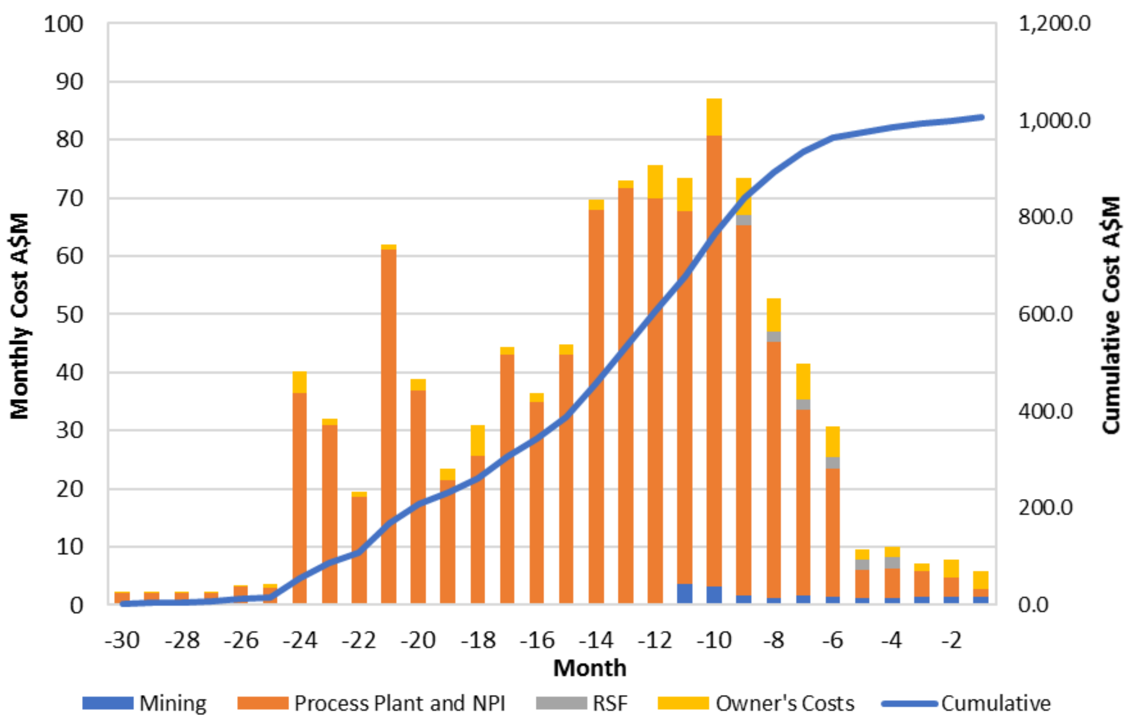
Table 40
Cost Maturity

Description	% of direct cost
Budget Quotes	47%
Validated Costs	19%
Historical Data	33%
Allowances	1%
Direct Costs	**100%**

12.15.4 Cashflow

A monthly cash flow of the capital costs has been developed based on the Project schedule. The cash flow is presented in Figure 25.

Figure 25
Project Capital Cash Flow



12.15.5 Deferred Capital

Table 41 outlines the capital cost estimate for sulphuric acid plant Modules 2 and 3.

Table 41
Sulphuric Acid Plant Modules 2 and 3 Capital Estimate

Description	A$M	Comment
Direct Costs	39.3	
Indirect Costs	1.2	3% of direct costs
Contingency	2.0	5% of (direct and indirect costs)
Total	**42.5**	
Spares & Inventory*	0.4	1% of direct costs
Operational Readiness	0.1	0.2% of direct costs
Owner's Project Management	0.4	1% of direct costs
Project Insurances	0.2	0.4% of direct costs
Owner's Project Indirects	0.2	0.6% of direct costs
Total	**43.8**	

* Spares for Modules 2 and 3 largely purchased as part of pre-production capital for the installation of Module 1, which is identical.

Table 42 outlines the capital cost estimate for the chlor-alkali plant and associated infrastructure.

Table 42
Chlor-alkali Plant Capital Estimate

Description	A$M	Comment
Direct Costs	45.4	
Indirect Costs	2.3	5% of direct costs
Contingency	4.0	8.5% (direct and indirect costs)
Total	**51.7**	
Spares & Inventory	1.8	4% of direct costs
Owner's Project Management	0.4	1% of direct costs
Owner's Project Indirects	0.3	0.6% of direct costs
Total	**54.2**	

12.15.6 Qualifications, Assumptions and Exclusions

The following items are noted as exclusions to the estimate:

- Sulphuric acid plant Modules 2 and 3 (deferred capital).
- Chlor-alkali plant (deferred capital).
- EPC risk premium (anticipated to be minimal with staged EPC contracting strategy).
- Sunk costs.
- Further studies prior to detailed engineering.
- Forward escalation from the estimate base date through to Project completion.
- Government levies and taxes.
- Working capital, sustaining capital and stay-in-business capital.
- Schedule acceleration costs.
- Schedule delays and associated costs, such as those caused by labour disputes and/or force majeure.

13 OPERATING COST ESTIMATE

13.1 Estimating Method and Accuracy Statement

The DFS operating cost estimate has been developed from first principles by category of cost type. This method is described in the subsequent sections.

The operating cost estimate has been developed in line with a Class 3 estimate with a target accuracy of ±15%. The date of the estimate is December 2018, presented in Australian dollars (A$) exclusive of GST.

13.2 Basis of Estimate

The operating cost estimate has been developed for three options:

- Scenario 1: Including a sulphuric acid plant (SAP) and no chlor-alkali (CA) plant.
- Scenario 2: Including a sulphuric acid plant and a chlor-alkali plant.
- Scenario 3: Excluding both the sulphuric acid plant and chlor-alkali plants.

Where adjustments in the operating costs occur for these three cases, an explanation will be provided in the breakdown.

13.3 Organisation Breakdown Structure

13.3.1 Structure of Estimate

The operating cost estimate has been built from first principles using the following categories:

- Mining
- Labour
- Energy
- Maintenance
- Laboratory
- Administration
- Consumables
- Reagents
- Transport and logistics (incoming reagents and consumables)
- Product transport

Key inputs, assumptions and methodology are outlined in detail in each section.

Sustaining capital costs have also been developed as part of the operating cost estimate and have been added as a below-the-line item.

Costs are considered as fixed or variable and an explanation given in each section below. Fixed costs are costs that do not vary with plant throughput and variable costs are costs that do vary with plant throughput. Variable costs have been considered variable to the following production metrics:

- Tonnes of ore throughput.
- Tonnes of concentrate produced.
- Tonnes of sulphuric acid required.
- Tonnes of P_2O_5 in MGA phosphoric acid produced.
- Kilograms of TREO produced.

13.3.2 Mining Costs

Direct mining operating costs are detailed in Section 3.6. Direct mining costs have been developed from the mine design, mining contractor quotations and mining and production schedule, and input directly into the cash flow forecast.

Indirect costs for mining include:

- Arafura management of the mining contractor.
- Maintenance of Arafura-owned mining infrastructure.
- Power supply to the mining area, including for use by the mining contractor.
- Water supply, dust control, raw and potable, to the mining area.
- Grade control assay costs.
- Mining general and administration costs.

These costs have been included in the operating costs and are included in the labour, maintenance, energy, mobile equipment, laboratory and administration costs detailed below.

13.3.3 Labour Costs

Labour costs have been calculated from first principles. Organisational charts and rosters were developed for the Project, as outlined in Section 8.3, and a human resources consultant was engaged to provide recommended salaries, associated on-costs (including superannuation and payroll tax) and allowances for each identified role.

Messing and accommodation costs have been included in the labour costs for all personnel based on budget quotations received from a third-party camp services provider. Costs have also been included in the overall labour cost estimate for all contractors, except for the camp service contractors where costs have been included in cost of providing the services.

Budget flight costs were provided by a commercial airline servicing Alice Springs from all capital cities in Australia.

The working rosters in Table 43 were adopted, based on the analysis provided by the human resources consultant, to calculate the messing and accommodation and FIFO travel costs.

Table 43
Roster Types

Roster Type	Days On	Days Off	Hours	Travel
Day shift	4	3	12	Drive in/out from Alice Springs
Back-filled day shift	14	7	12	FIFO Alice Springs
Continuous shift	14	7	12	FIFO Alice Springs
Alice Springs	5	2	8	Not applicable
Laboratory (Contract)	8	6	12	FIFO Alice Springs
Power station (Contract)	14	14	12	FIFO Alice Springs

13.3.4 Energy

Natural Gas

Natural gas is required for electricity generation, steam production and process use in oil heaters and product dryers and kilns. Table 44 presents the natural gas requirements for the three operating scenarios.

Natural gas consumption for steam and process use is an output of the mass balance and considered a fixed cost. Natural gas consumption for electricity is also considered a fixed cost.

The inclusion of a sulphuric acid plant eliminates the gas-fired steam generation requirement. In this scenario, waste heat from the acid plant is utilised as steam for the process plant.

Table 44
Natural Gas Consumption Breakdown

Component	1. Inc SAP excl CA PJ/annum	2. Inc SAP and CA PJ/annum	3. Excl SAP and CA PJ/annum
Process Use	0.43	0.43	0.43
Steam	Stand-by only	Stand-by only	0.88
Electricity	2.45	2.80	2.24
TOTAL	**2.88**	**3.23**	**3.55**

Electricity

The operating cost of providing power to the plant is treated as a fixed operating cost as electrical requirements were not assessed as being variable to plant throughput.

A BOO model has been adopted in which all power generation costs are incorporated as operating costs. Costs for power are broken into fixed and variable components. Variable costs vary with electricity consumption, and fixed costs are applicable to items that do not differ with energy consumption.

The key inputs required to determine the annual cost of power are:

- Electrical load calculation.
- Contract gas price.
- BOO power plant fixed and variable costs.
- AGP connection fixed cost.
- Gas transport fixed cost.
- Gas management fixed cost.

The variable annual electricity cost incorporates expenses that are attributable to gas consumption on a gigajoule (GJ) basis and BOO charges on a per kilowatt hour (kWh) basis.

- Gas consumption was calculated as the product of operating load, utilisation, availability and gas engine heat rate.
- The contract natural gas price of $6.12 per GJ has been provided by a gas consultant and confirmed by a gas supplier.
- The variable BOO charge of 2.15 c/kWh was applied to the annual electricity consumption to determine the variable component of the contracted power cost.

The fixed component of the energy operating cost was determined by the summation of power station contract costs, gas pipeline costs and gas contract management costs.

Table 45 summarises the cost of each component listed above:

Table 45
Electricity Cost Breakdown

		1. Incl SAP excl CA	2. Incl SAP and CA	3. Excl SAP and CA
Variable Charges				
Variable power station cost	c/kWh	2.15	2.15	2.15
Gas heating value (HHV)	MJ/kWh	9.75	9.75	9.75
Natural gas cost	A$/GJ	6.12	6.12	6.12
Total annual usage	MWh/a	251,607	286,809	229,699
Annual variable gas cost	A$M/a	15.0	17.1	13.7
Annual variable station cost	A$M/a	5.4	6.2	4.9
Annual variable total cost	**A$M/a**	**20.4**	**23.3**	**18.6**
Fixed charges				
Annual capacity charge	A$M/a	6.6	7.3	6.3
AGP transport cost	A$M/a	2.0	2.3	2.5
AGP connection cost	A$M/a	1.7	1.9	2.1
Gas management cost	A$M/a	0.03	0.03	0.03
Annual fixed total cost		**10.3**	**11.4**	**10.8**
Annual total electricity cost		**30.8**	**34.7**	**29.5**
Unit cost of electricity		12.22	12.11	12.83

13.3.5 Maintenance

Maintenance costs are considered fixed annual costs and include the cost of spare parts (other than operating consumables), maintenance consumables and maintenance contracts to maintain the process plant and non-process infrastructure.

Maintenance contracts include the labour, transport and messing and accommodation costs for shutdown and specialised maintenance activities. Shutdown contract labour was calculated based on activity and frequency of required shutdowns. The following specialised shutdowns were included on this basis:

- Boiler package major inspection and maintenance overhauls.
- Crusher and SAG mill relines.
- Acid plant general overhaul.

Direct labour charges for routine maintenance is included in labour costs.

Maintenance costs were determined as a factor of capital mechanical and electrical equipment costs. The factors were based on analysis of the type equipment located in each area and range between 1.5% and 5% of mechanical equipment cost and equal 5% of electrical equipment cost.

Additional maintenance activities were included, and costs have been allocated as follows:

- Site access road maintenance has been estimated at A$50,000 per year.
- Road maintenance for the plant roads was estimated at A$40,000 per kilometre per year to total A$80,000 per annum.
- Road maintenance for the mine access road was estimated at A$20,000 per kilometre per year to total A$190,000 per annum.
- Road maintenance for the haul roads is included in the direct mining costs.
- Yard maintenance has been included as an allowance of A$125,000 per annum.
- Building and general maintenance is estimated at 1% of direct capital, equating to A$198,362 per annum.
- Mobile equipment maintenance, excluding mining equipment, has been calculated for each item and considers tyres, drive trains, brakes, oil/lube and general maintenance, equating to A$178,290 per annum.
- Maintenance of each genset has been calculated based on typical contract provisions, equating to A$38,016 per annum.
- Control system maintenance has been estimated at A$70,000 per annum.

13.3.6 Laboratory

The laboratory cost estimate includes costs for the analysis of blast-hole grade control samples and routine plant samples at an on-site facility operated by a contractor. The contractor will supply the required laboratory equipment, staff, maintenance and consumables, with Arafura providing the laboratory building.

A sample analysis schedule was developed and forms the basis of the laboratory cost estimate. The schedule incorporated number and frequency of samples as well as the type of analysis required. An annual allowance was made for offsite analysis of samples for quality control purposes.

13.3.7 Administration

Administration costs are considered fixed costs and are itemised in Table 46.

Table 46
Administration Operating Costs

Category	**Cost A$/annum**	**Basis of estimate**
Software	160,600	Based on headcount and quotations
ERP Costs	54,000	Quotation
Site offices	0	
Communications	404,280	Quotation
Office Expenses	210,700	Allowances
Insurances	0	
Industrial special risk/Business Interruption	1,693,100	Quotation based on cost schedules
Workers' compensation	847,855	4% of salary
Other	194,000	Allowance
Land lease fees	150,000	Allowance
Consultants	0	
Geology	5,000	Allowance
Mining	80,000	Allowance
Metallurgy	203,390	Allowance
Tailings dam auditing	25,000	Allowance
Environment & OHS	187,500	Allowance
Equipment & consumables	39,950	Allowance
Personnel	0	
Business as usual recruiting	192,750	HR study
Safety clothing/PPE etc.	200,464	Calculation
First aid, medical, D&A tests	33,000	132 people at A$250 each.
Other	305,000	Allowance
Training	529,909	2.5% of salary
Contracts	0	
Bussing Alice Springs – Site	412,949	Quotation
Cleaning	448,342	Quotation
Other	145,000	Allowance
General	0	
Waste/waste water collection	420,000	A$35,000 per month
Miscellaneous	27,000	Allowance

13.3.8 Consumables

Consumables have been considered to have fixed elements and variable components depending on the equipment they service.

Specialised consumables for mechanical equipment are considered variable costs as their replacement is variable to the throughput of associated equipment. The consumable wear rate was determined from vendor data and best practices. Consumable consumption and costs are shown in Table 47.

Table 47
Mechanical Equipment Consumables

Consumable	Unit Cost (A$)	Annual Consumption	Source
MMD sizer consumable	248,982 /set	0.5 set	Quote – includes 5% T&L
SAG mill liner	380,741 /set	1 set	Quote – includes 10% T&L
SAG mill feed chute liner	45,042 /set	1 set	Quote – includes 10% T&L
SAG mill wear ring	3,043 each	1	Quote – includes 10% T&L
SAG mill grinding media	1,500 /kg	277 kg	Database
Plate and frame filter cloths	292 – 400 /filter	Varying per filter	Quote
Polishing filter candles/cloths	300 – 600 /filter	Varying per filter	Quote
Dust collector filter bags	300	6	Quote
IX resin replacement	25,500	10 m^3	Quote

Product packaging consumables are detailed in Table 48. These requirements vary with production rates and are therefore considered variable.

Table 48
Product Packaging Consumables

Consumable	Unit Cost (A$)	Annual Consumption	Source
Cerium bulk bags	11 /bag	10,456 bags	Quote
Cerium bulk bag pallets	27 /pallet	10,456 pallets	Quote
NdPr oxide drums and lids	100 /drum	8,516 drums	Quote
NdPr oxide drum pallets	57 /pallet	2,129 pallets	Quote
NdPr Kevlar strapping	83 /coil	85 coils	Quote
SEG/HRE carbonate drums and lids	100 /drum	2,049 drums	Quote
SEG/HRE carbonate drum pallets	57 /pallet	512 pallets	Quote
SEG/HRE carbonate Kevlar strapping	83 /coil	20 coils	Quote

Table 49 shows fixed cost consumables. Boiler and cooling tower chemicals have been allocated as an allowance. Water treatment chemical consumption is based on the flowrate, which is considered to be fixed. The diesel allocation considers mobile equipment, diesel generators and bus service fuel consumption.

Table 49
Fixed Cost Consumables

Consumable	Unit Cost (A$)	Annual Consumption	Source
Boiler chemicals	200,000	Allowance	
Cooling tower chemicals	100,000	Allowance	
Diesel	0.96 /litre	1,962,061 litres	Quote
Water treatment			
Potable Water	0.03 /m^3	17,666 m^3	Database
RO Plant	0.28 /m^3	891,777 m^3	Database
Demineralised Water	0.47 /m^3	459,594 m^3	Database
Genset consumables	8,000	Allowance	

13.3.9 Reagents

Reagent costs are considered variable costs with consumption varying dependent on plant throughput, chemistry requirements or final production. Consumption rates are based on the mass balance at specified supply concentrations. Reagents costs are based on a delivered to Darwin or Adelaide basis.

Sulphur

Sulphur has been priced using an analysis of historical and forecast sulphur pricing, international shipping rates and port charges for Darwin Port. The cost presented in the operating cost estimate is a combination of:

- Elemental sulphur price in 2018 US dollars, FOB Canada.
- Sulphur purchasing brokerage fee of 3%.
- International shipping component in US dollars to Darwin provided by a global shipping broker.
- US dollar to Australian dollar exchange rate as defined for the Project.
- Local costs which include customs and wharfage.

Sodium Hydroxide

Sodium hydroxide supply has been priced based on analysis of historical and forecast pricing provided by a large Australian reagent supplier. In addition, costs for international shipping, port charges, storage charges and other costs have also been provided by the supplier. The cost presented in the operating cost estimate is a combination of:

- Sodium hydroxide price in 2018 US dollars, FOB Asia.
- International shipping component in US dollars to Port Adelaide.
- US dollar to Australian dollar exchange rate as defined for the Project.
- Local costs which include customs, wharfage and storage.

Hydrochloric acid

The hydrochloric acid supply cost has been based on forecast pricing provided by a large Australian reagent supplier. Importation of acid in isotainers has been selected for the basis of the DFS. Freight rates for the transportation of isotainers from Asia to Darwin have been provided by a global shipping company. The cost presented in the operating cost estimate is a combination of:

- Hydrochloric acid price in 2018 US dollars, FOB Asia.
- US dollar to Australian dollar exchange rate as defined for the Project.
- International shipping of containerised acid to Darwin.
- Darwin Port wharfage charges.

Hire costs for the required hydrochloric acid isotainers is included in the transport and logistics costs as provided by Qube. The hire rate includes routine inspections and necessary maintenance of containers.

Importing bulk shipments of hydrochloric acid remains an opportunity for the Project although with the future inclusion of a chlor-alkali plant, and therefore a finite period of purchasing acid, this option presents some risks. They include:

- Bulk importation of HCl requires a bulk storage facility to be constructed at either Darwin or Adelaide. The costs for a purpose-built tank at Darwin Port and subsequent leasing fees have been investigated and total A$2.2M per year for the first 10 years. After 10 years the leasing cost drops to A$0.5M.
- Only one bulk HCl shipping vessel exists in Asia and its availability to service the Project is uncertain. Clarity surrounding the use of this vessel will not be available until reagent supply contracts are made for the Project.

Sodium carbonate (dense soda ash)

Sodium carbonate requires humidity-controlled conditions to avoid aggregation. Therefore, Adelaide was the only port considered for the importation of this reagent. Three quotations were received for sodium carbonate, and the lowest price was incorporated in the operating cost estimate.

Quicklime

Three quotations were received for quicklime, and the lowest price was incorporated in the operating cost estimate.

Salt

In the case of Scenario 2 where a chlor-alkali plant is incorporated into the process plant, the main raw material required is salt. Two quotations were received for high purity salt delivered in bulk to Darwin Port.

Small quantities of various other reagents will be required. These have been costed within the scenario and are listed in Table 50.

Table 50
Chlor-alkali Plant Reagent Consumption

Reagent	Quantity	Units
Hydrogen peroxide	45	tpa
Sodium carbonate	212	tpa
Barium chloride	183	tpa
Chelating resin	141	L/a
Activated carbon	141	L/a
Flocculant	0.6	tpa
Precoat and filter aid	11.3	tpa

Single quotations were received for the remainder of reagents either due to the speciality of the reagent or the low annual consumption. The total reagent requirement for the process plant with the inclusion of a sulphuric acid plant is summarised in Table 51.

Table 51 Reagent Cost and Consumption			
Reagent	**Unit Cost (A$)**	**Consumption Rate (t/y)**	**Source**
Sulphur	217	78,540	Historical & forecast data/shipping quote
Sodium hydroxide (50%)	402	46,890	Historical pricing analysis/shipping quote
Hydrochloric acid (32%)	336	36,194	Product quote/shipping quote
Sodium carbonate (DSA)	425	19,308	Supplier quote
Precipitation agent	760	2,628	Historical pricing analysis/shipping quote
Quicklime	197	4,825	Supplier quote
Sodium silicate	631	2,683	Supplier quote
Hydrogen peroxide (70%)	910	1,973	Supplier quote
Oleic acid	1,436	1,486	Supplier quote
Barium chloride	2,319	567	Supplier quote
Flocculant	3,400	382	Supplier quote
Coagulant	2,600	423	Supplier quote
Diluent	1,800	75	Supplier quote
Magnesia	1,015	81	Supplier quote
Hydrated lime	298	45	Supplier quote
Surfactant	500	16	Supplier quote
P507 Extractant	9,000	15	Supplier quote

Sulphuric acid

In the case of no acid plant, all sulphuric acid requirements are to be purchased. Sulphur and other necessary acid plant reagents are excluded.

Sulphuric acid quotations from two sources have been obtained, one for bulk import into Darwin and one as a by-product from a domestic Australian smelter (indicative price sourced from logistics company).

The cost difference between the two acid supply scenarios is A$4.1M per annum in favour of purchasing from the domestic source. The associated costs are detailed in Table 52.

Table 52 Sulphuric Acid Purchase Options		
	Acid Import	**Domestic Purchase**
Acid Purchase	US$99/t	A$237/t
Local costs	A$32/t	Incl.
Domestic transport to site	A$81/t	Incl.
Total variable costs	A$249.93/t	Incl.
Isotainer hire	A$884,760/a	Incl.
Annual total cost	**A$61,467,741**	**A$57,327,710**

13.3.10 Transport and Logistics

Qube was engaged to develop the operating costs related to transport and logistics of incoming reagents and consumables as well as outgoing products. Additionally, the cost of transporting products is separated from the general transport and logistics estimate.

Transport and logistics costs are presented on a fixed and variable basis. Fixed costs include the hiring and maintenance of shipping containers and liquid isotainers required for transporting reagents to site. The container hire costs for Scenario 1: including acid plant, excluding chlor-alkali plant, are detailed in Table 53.

Table 53
Transport and Logistics Fixed Container Costs – Scenario 1

Component	Quantity	Daily Rate A$	Annual Cost A$
Sulphur	112	2.82	115,282
Hydrochloric acid	300	29.04	3,179,880
Sodium hydroxide	37	29.04	392,185
Quicklime	5	12.60	22,995
Sodium carbonate	8	12.60	36,792
Hydrogen peroxide	2	50.00	36,500
Precipitation agent	20	50.00	365,000

Also included in the fixed cost category are leasing costs for staging yards, labour, equipment, storage facilities and logistics contractor annual charges. These costs total A$4.05M per year.

Provision has also been made for the transportation of one standard shipping container from both Adelaide and Darwin each week to site at an annual cost of A$310,000.

Alterations to this fixed cost schedule will occur for Scenarios 2 and 3 as follows:

- Scenario 2 – If a chlor-alkali plant is included additional infrastructure is required to store salt at Darwin Port. An additional cost will be incurred for a salt shed. Hydrochloric acid isotainers are excluded, and the quantity of caustic containers reduces to 17. These changes result in a A$2.75M saving per year when compared to Scenario 1.
- Scenario 3 – If no sulphuric acid plant or chlor-alkali plant is included. The sulphur shed and sulphur container costs are replaced with that of hiring 101 sulphuric acid isotainers. The overall fixed cost increase if no acid plant is included compared with Scenario 1 is A$0.16M per year.

Variable costs for transport and logistics relate to the movement of reagents to site. The variable cost provided by the consultant includes:

- Sulphur vessel stevedoring, handling and containerisation of sulphur.
- Loading of isotainers from bulk liquid storage tanks (if applicable).
- Road transportation from Darwin or Adelaide ports to relevant rail terminal.
- Rail haulage of containers and isotainers to Alice Springs.
- Road transportation of containers and isotainers to site.
- Returning of empty containers and isotainers to port of origin.

Costs for reagent transportation of between A$118 and A$200 per tonne have provided and are based on:

- Port of origin.
- Capacity of container or isotainer.
- Specific handling duties required for each reagent and container or isotainer.

13.3.11 Product Transport Costs

Operating costs associated with transporting all products beyond the mine gate are classified as product transport costs. These are both fixed and variable in nature. Fixed costs are presented in Table 54.

Table 54 Product Transport Fixed Costs			
Component	**Quantity**	**Rate**	**Annual total A$**
Phosphoric acid isotainers	99	A$24.00 / day	867,240
Phosphoric acid bulk storage tank	1	A$344,151 / month	4,129,809
Marine insurance		0.01% of product value	60,163

The variable cost of transporting products to Darwin Port varies between A$139 and A$169 per tonne depending on:

- Capacity of containers or isotainers.
- Specific handling requirements at site or port for each product.

13.4 Sustaining Capital

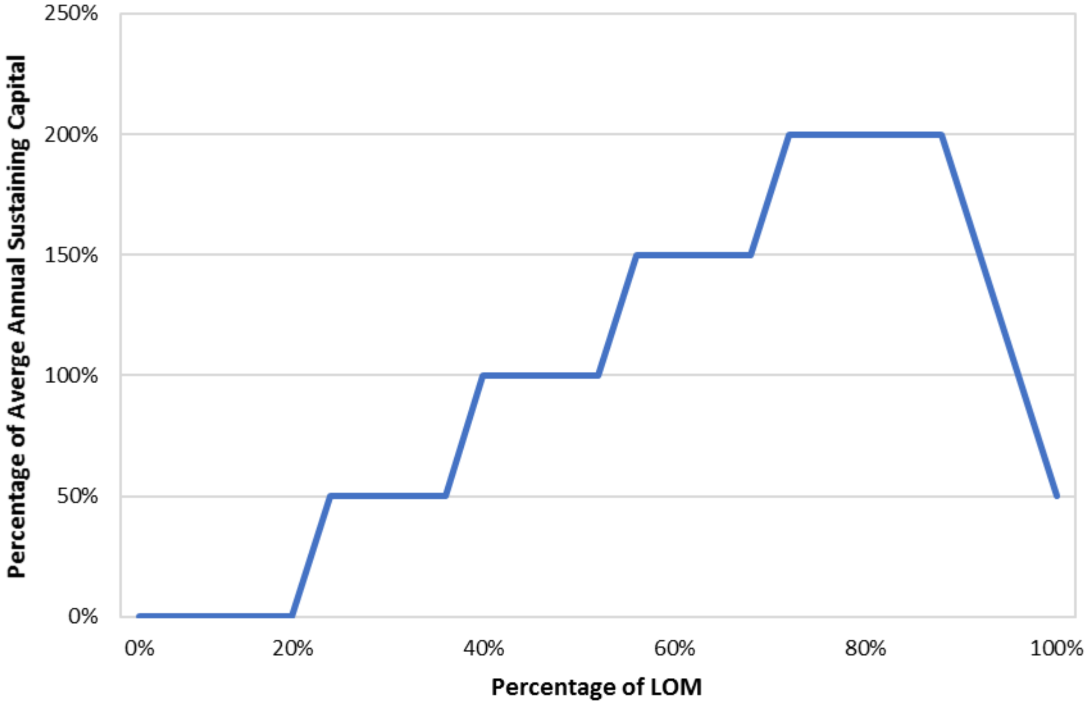
Sustaining capital has been estimated as a below-the-line item as part of the operating costs and covers the funding required over the life of the Project to replace equipment at the end of its useful life or planned expenditure to modify the plant as necessary to sustain operations at the rated capacity.

General sustaining capital was estimated by applying factors to direct costs, excluding earthworks. Table 55 summarises the factor applied for each discipline. These calculations were systematically completed for each area of the plant.

Table 55 General Sustaining Capital Factored Estimate	
Discipline	**Factor (%)**
Concrete	0.25
Structural steel	1.0
Architectural	1.0
Piping	1.5
Mechanical equipment	1.5
Electrical	1.5
Sulphuric Acid/Chlor-alkali Plant	0.5
Pipelines	0.5
Bores	1.5
IT	Allowance

The annual general sustaining capital cash flow has been spread over the LOM in a ramp-up style distribution that depicts the expected expenditure pattern. Figure 26 below shows the distribution that has been applied to the cash flow forecast model. The average general sustaining capital spent over the LOM is equal to the annual expenditure calculated by the factored estimate.

Figure 26
Sustaining Capital Distribution over LOM



Additional long-term items are included directly in the cash flow model when expenditure is forecast to occur. These items are:

- Mining sustaining capital – annual average over LOM, primarily costs associated with in-mine water control and additional equipment mobilisation based on the increase in mine production requirements.
- RSF lifts – annual average over the life of mine. This value excludes final closure but includes interim closure costs.
- Debottlenecking capital incurred over the ramp up period, included at A$20 M during the first and second years of operation.
- Roads – annual average for re-sheeting of internal roads.
- Surface water management relating to the diversion of Kerosene Camp Creek around the mining area.
- Geological grade control.

13.5 Accuracy

The target accuracy of the estimate is ±15%.

13.6 Presentation of Estimate

The operating cost model has been prepared based on the SysCAD mass balance, which represents the nominal production, as opposed to the average LOM production, and has an ore throughput of 893,641 tonnes per annum (tpa) of ore to produce the following:

- 4,237 tpa of NdPr oxide.
- 8,534 tpa of Ce hydroxide (TREO equivalent).
- 581 tpa of SEG/HRE carbonate (TREO equivalent).

This results in an annual nominal production of 13,351 tpa of TREO and 136,997 tpa of MGA phosphoric acid.

The beneficiation plant availability is 8,000 hours per annum while the process plant availability is 7,500 hours per annum. The estimate has been prepared in Australian dollars and is correct as at the 4th quarter of 2018.

A summary of the operating cost estimate is presented in Table 56 and Table 57 with a distribution is provided in Figure 27.

Table 56
Nominal Operating Cost Estimate Summary by Category

Category	**1. Incl SAP excl CA**		**2. Incl SAP and CA**		**3. Excl SAP and CA**	
	A$M per annum	**A$/kg TREO**	**A$M per annum**	**A$/kg TREO**	**A$M per annum**	**A$/kg TREO**
Mining**	39.1	2.93	39.1	2.93	39.1	2.93
Labour	24.2	1.81	25.8	1.93	24.6	1.84
Reagents*	69.2	5.18	48.4	3.62	93.2	6.98
Consumables	7.1	0.53	7.1	0.53	7.1	0.53
Energy	33.4	2.50	37.4	2.80	37.5	2.81
Maintenance	10.6	0.80	11.2	0.84	10.0	0.75
T&L	34.5	2.58	26.2	1.96	44.9	3.36
Laboratory	2.6	0.20	2.6	0.20	2.6	0.20
Administration	6.9	0.52	7.0	0.53	6.9	0.52
Product Transport Costs	26.7	2.00	26.7	2.00	26.7	2.00
Sub Total	**254.3**	**19.05**	**231.5**	**17.34**	**292.7**	**21.92**
Sustaining Capital	10.4	0.78	10.6	0.79	10.0	0.75
Total	**264.7**	**19.82**	**242.1**	**18.13**	**302.7**	**22.67**

*Sulphuric acid purchase from chemical trader.

** Mining operating costs are the average direct mining operating costs based on the base case mining schedule. Owner's mining costs are included in labour, consumables, maintenance and administration.

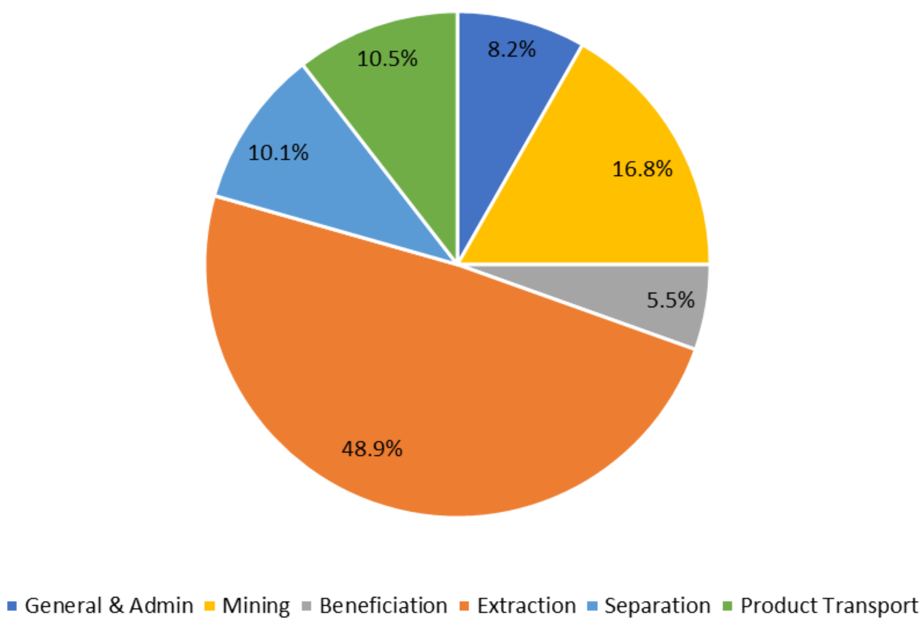
Table 57
Nominal Operating Cost Estimate Summary by Area

Category	1. Incl SAP excl CA		2. Incl SAP and CA		3. Excl SAP and CA	
	A$M per annum	A$/kg TREO	A$M per annum	A$/kg TREO	A$M per annum	A$/kg TREO
Mining**	42.6	3.19	42.6	3.19	42.6	3.19
Beneficiation	13.9	1.04	13.9	1.04	14.2	1.07
Extraction	124.5	9.32	107.2	8.03	161.9	12.12
Separation	25.7	1.93	20.1	1.50	26.1	1.95
General & Administration	21.0	1.57	21.1	1.58	21.1	1.58
Product Transport	26.7	2.00	26.7	2.00	26.7	2.00
Sub Total	**254.3**	**19.05**	**231.5**	**17.34**	**292.7**	**21.92**
Sustaining Capital	10.4	0.78	10.6	0.79	10.0	0.75
Total	**264.7**	**19.82**	**242.1**	**18.13**	**302.7**	**22.67**

*Sulphuric acid purchase from chemical trader.

** Mining operating costs are the average direct mining operating costs based on the base case mining schedule plus allocation of owner's mining costs.

Figure 27
Scenario 1 Operating Costs by Area



13.7 Cash Flow Forecasting

The operating cost cash flow forecast was prepared in quarterly periods from the mining schedule and operating cost model. The mining schedule provides the material types, tonnage and head grade of ore on a quarterly basis as well as direct mining costs. The schedule also reports the following process plant anticipated physicals:

- Concentrate production tonnage.
- Sulphuric acid requirement.
- MGA phosphoric acid production.
- TREO production.

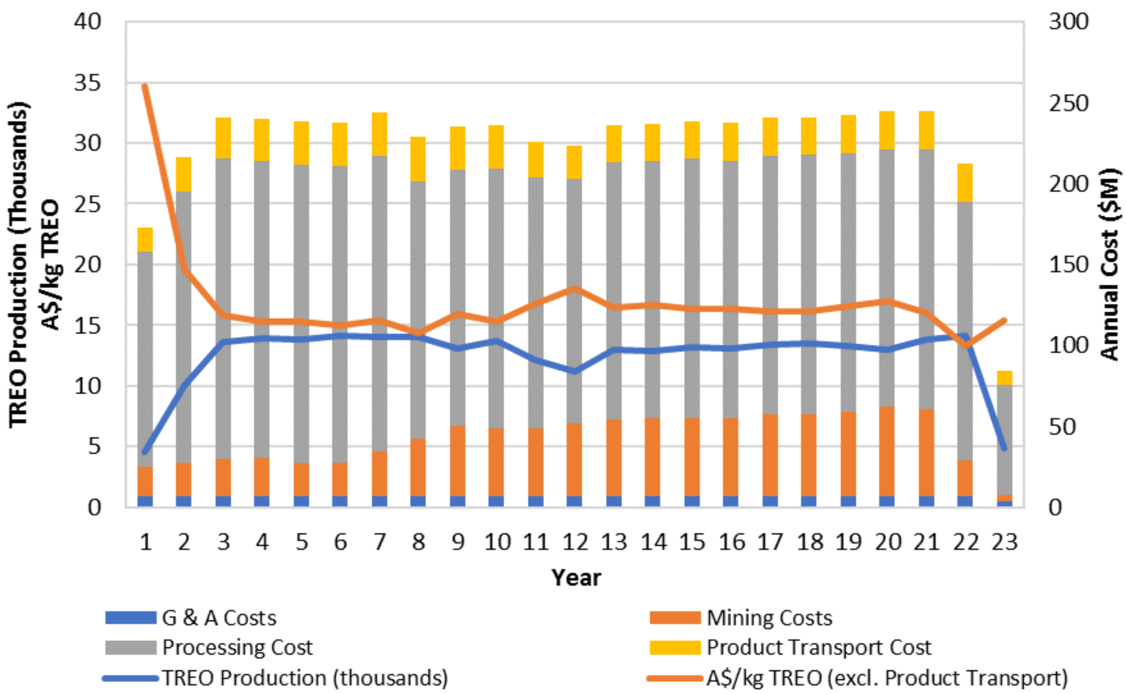
The operating cost model has been prepared in a manner to maximise its flexibility. Although the model is static in nature, the output has been designed to allow application to the variability of plant throughput. The operating cost model reports costs for inclusion into the financial model as:

- Fixed.
- Variable to ore throughput.
- Variable to concentrate production.
- Variable to sulphuric acid requirement.
- Variable to MGA phosphoric acid production.
- Variable to TREO production.
- Average fixed general sustaining capital cost.

In addition, these costs are identified in native currency for use in the financial modelling of the Project.

Operating costs calculated on this basis, at the fixed exchange rate used for the operating cost model, are shown in Figure 28.

Figure 28
Operating Costs Over LOM



13.7.1 Ramp-Up

To assist with ramp-up of the Project additional costs have been allowed during the three-year ramp-up period. These include:

- Labour. Additional operations, maintenance and technical staff have been included commencing at an additional 15 personnel and reducing over the ramp-up period.

- Reagents, including transport and logistics of these reagents. Commencing at 25% additional reagent usage rate for the first year, reducing to 15% for year two and 5% in the final year of ramp-up.

- Consultants and other costs. Allowances have been included for additional consultants to assist in the ramp-up along with other costs, primarily relating to travel and accommodation for equipment and other vendors.

During the ramp-up period the variable operating costs for energy (primarily gas) have also been scaled with the anticipated utilisation of the various areas of the plant.

13.8 Exclusions

The following has been excluded from the operating cost estimate:

- Capital costs (including initial fills).
- GST.
- Costs associated with borrowing, Joint Ventures or any other financial arrangement associated with Project funding.
- Corporate costs including:
  - Payments to native title holders.
  - Alice Springs office lease and operations.
  - Product marketing.
  - Banking, legal and auditing fees.
  - Tenement fees.
  - Community relations expenses.
  - Conferences and subscriptions.
- Deferred capital (see Section 12.14).
- Closure and rehabilitation.

14 MARKETING

14.1 Rare Earth Market

The use of rare earths in the magnet sector represents the single largest rare earth application, accounting for 26% of consumption. The use of NdFeB magnets in the automotive and factory automation sectors is the biggest growth application for Nd demand growing from 12% in 2005 to 23% by 2018. The growth in NdFeB magnets since 2005 is attributed to increased use in the automotive industry, in particular electric traction drive trains and electric power steering, and the forecast worldwide expansion of NEVs will increase demand for NdPr oxide used in magnets.

The EV market exceeded one million sales in 2017 (Bloomberg NEF 2018)[2] and is approaching two million in 2018 with the majority of sales and forecast growth in China. The NEV market, comprising EVs and hybrid EVs (HEV), reached 12 million vehicles in 2018.

Roskill's baseline outlook for NEV penetration including hybrids in 2025 and 2030 is 67% and 88% respectively, with forecast sales of 78 million and 110 million units.[3] By far the largest EV growth contributor will be China representing 51% of the global volume. More than 75% of OEMs are expected to use only electric powertrains on their dedicated platforms by 2025, automakers have announced aggressive future EV plans over the next 10 years, and the number of EV models is set to rise.

14.1.1 Rare Earth Market Demand and Forecast

The global rare earth industry has grown at a compound annual growth rate (CAGR) of 5.3% from 2000 to 2008 and a CAGR of 5.1% since 2012. Rare earths remain critical in various applications with future REO demand expected to remain strong driven by the clean energy economy. Roskill forecast global consumption of rare earths of 137,000 tonnes of TREO in 2018 on the back of increased consumption of NdPr oxide in NdFeB magnets.

Global demand for rare earths is forecast to increase by a CAGR of 3.9% over the next six years to 2024, reaching 172,000 tonnes of TREO, before slowing to 2.2% per annum over the following six years to reach 196,000 tonnes in 2030. China will continue to dominate global markets, strengthen its supply chain and increase the use of rare earths in clean energy technology and e-mobility with expected strong growth for NdPr oxide in NdFeB magnets.

14.1.2 Magnet Demand

In 2016, the annual output of NdFeB magnets was 134,949 tonnes (according to the Association of China Rare Earth Industry)[4] and over the past decade grew at a compound annual growth rate (CAGR) of 8-10%. Magnets are forecast to grow by 7% per annum in the foreseeable future with demand for NdFeB magnets reaching 184,975 tonnes in 2025. Magnet use in drivetrains is forecast to account for 62% of the share of total demand by 2030 (Figure 29).

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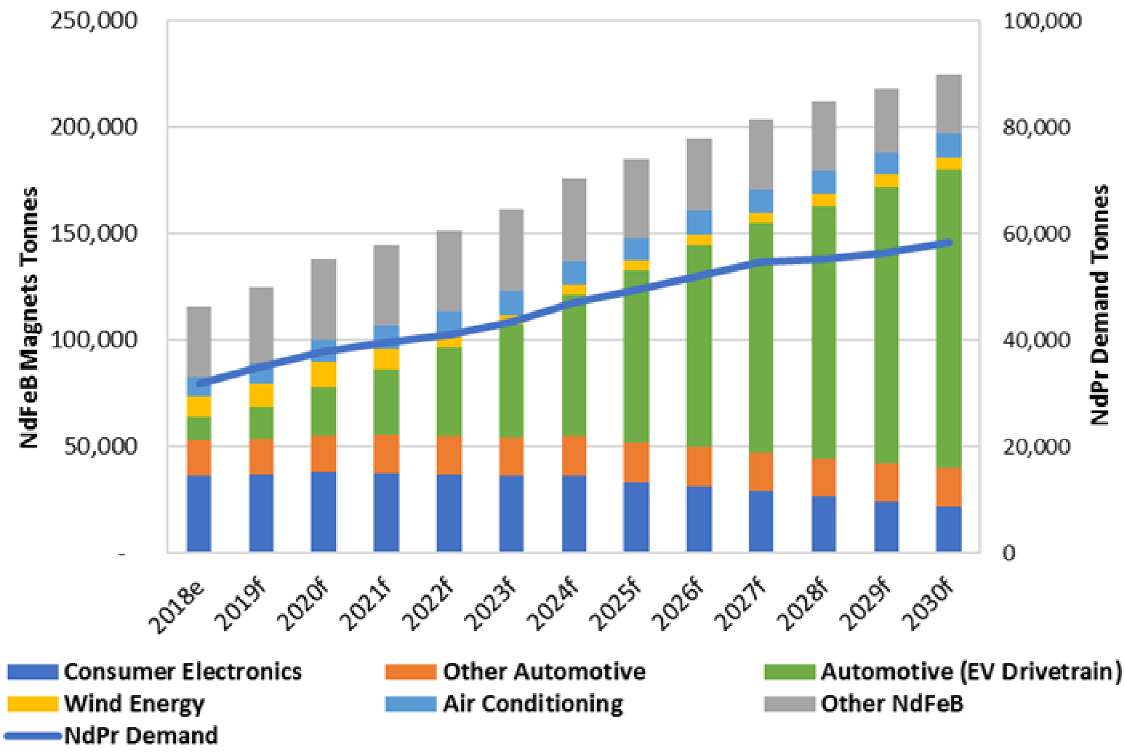
[2] https://about.bnef.com/electric-vehicle-outlook/#toc-download

[3] Roskill Consulting Group, Rare Earths Market Analysis for Arafura Resources, November 2018

[4] Curtin-IMCOA, Rare Earths Supply today, October 2018

Figure 29
Forecast NdFeB Magnet Demand to 2030



14.1.3 Global Rare Earth Supply

Rare earth supply is dominated by Chinese producers accounting for 80% of global supply in 2018. Total dependence on Chinese domestic supply has been reducing since 2015 with increased external supply from Malaysia, USA, Russia, Vietnam and India.

Continued implementation and enforcement of Chinese Government policy will restrict future domestic supply. When coupled with projected strong demand for NdPr oxide, China will, ‘under clear policy’, seek additional supply outside the mainland. To meet projected demand over the next decade, additional supply is expected to be developed in Australia, North America and Africa, and China’s grip on global supply is expected to reduce to around 60% by 2030 according to Roskill.

Chinese rare earth policy has had a significant impact on global supply over the past 10 years and the focus of recent initiatives by the Chinese Government has been on:

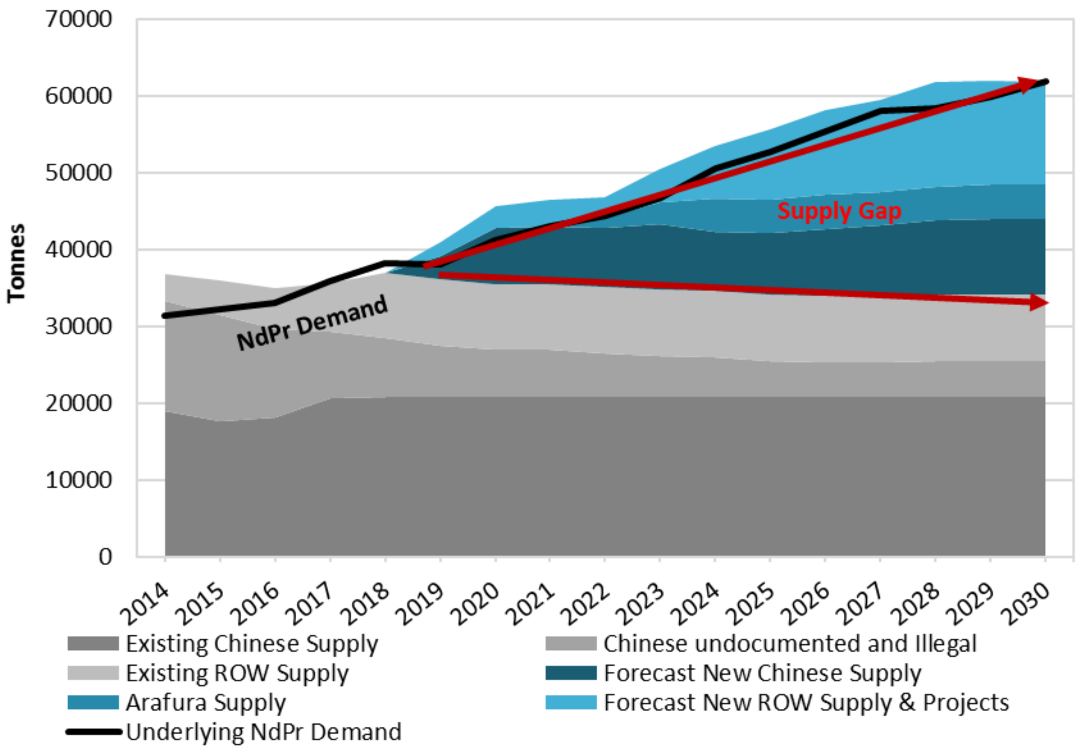
- Preservation of rare earth reserves.
- Strengthening environmental regulations and closing down illegal mining and processing including regular government inspections causing supply disruptions.
- Preferred export of value-added products like NdFeB magnets.
- Strategic materials stockpiling of Nd, Pr and Dy for domestic consumption.

China's continued industry consolidation and increased demand for its own rare earths will place significant long-term pressure on exports of NdPr. The growing Chinese NEV market will place NdPr oxide supply to international customers at risk with preference to supply NdPr to Chinese magnet producers and the domestic automotive industry.

Official Chinese rare earth production in 2018 was 115,000 tonnes of TREO, equating to 20,700 tonnes of NdPr oxide with the total global supply at 37,000 tonnes of NdPr oxide from ROW and illegal supply sources. To meet projected demand for NdPr oxide in 2030, global supply needs to expand by 26,500 tonnes, equivalent to another 115,000 tonnes of TREO. At the same time, the proportion of illegal and undocumented Chinese supply is forecast to reduce from 27% to 14% over the next decade through continued government control.

Roskill's supply demand outlook is showing a substantial supply gap emerging for NdPr oxide (Figure 30). To meet this future supply requirement, supply growth of 25,000 tonnes is required over the next decade.

Figure 30
NdPr Supply and Demand Forecast



14.2 Phosphoric Acid Market

The global phosphoric acid market in 2017 was approximately 45 Mt of contained P_2O_5. It is predominantly used in fertilizer production and the market expanded at a CAGR of 2.0% during 2012-2017. Fertilizer demand is driven by intensive crop farming, food demand and higher value food consumption in developing countries. Di-ammonium phosphate (DAP) production made up 30% of P_2O_5 consumption in 2017.[5]

The majority of phosphoric acid production is not available for trade and is consumed by integrated fertilizer plants in China, North Africa and the Middle East. In 2017, 4.4 Mt of phosphoric acid (P_2O_5) was traded, making up approximately 10% of global consumption. India consumes 2.4 Mt of P_2O_5, or approximately 50% of the traded phosphoric acid, largely imported from producers in Morocco, Jordan, Tunisia and Senegal. Consumption in India over the past five years has increased due to growth in DAP and nitrogen, phosphorous and potassium (NPK) fertilizer demand reaching a CAGR of 4.4% to 2017.

Future phosphoric acid production and traded supply is driven by increased demand for DAP and NPK fertilizers in the Asia Pacific region. The long-term forecast by CRU to 2027 predicts a tightening supply of phosphoric acid with continued increased demand for DAP and NPK fertilizers in the Indian and other Asian markets. The main drivers of phosphoric acid imbalance over the forecast period are:

- Asian countries such as Indonesia, Vietnam, and Pakistan are forecast to increase acid demand and Indian acid imports are expected to grow (with DAP demand) from 2.4 Mt to 2.8 Mt P_2O_5 over the forecast period.

- No capacity additions are planned in the Asia Pacific region and the majority of planned future acid capacity additions by Morocco and others are for internal use.

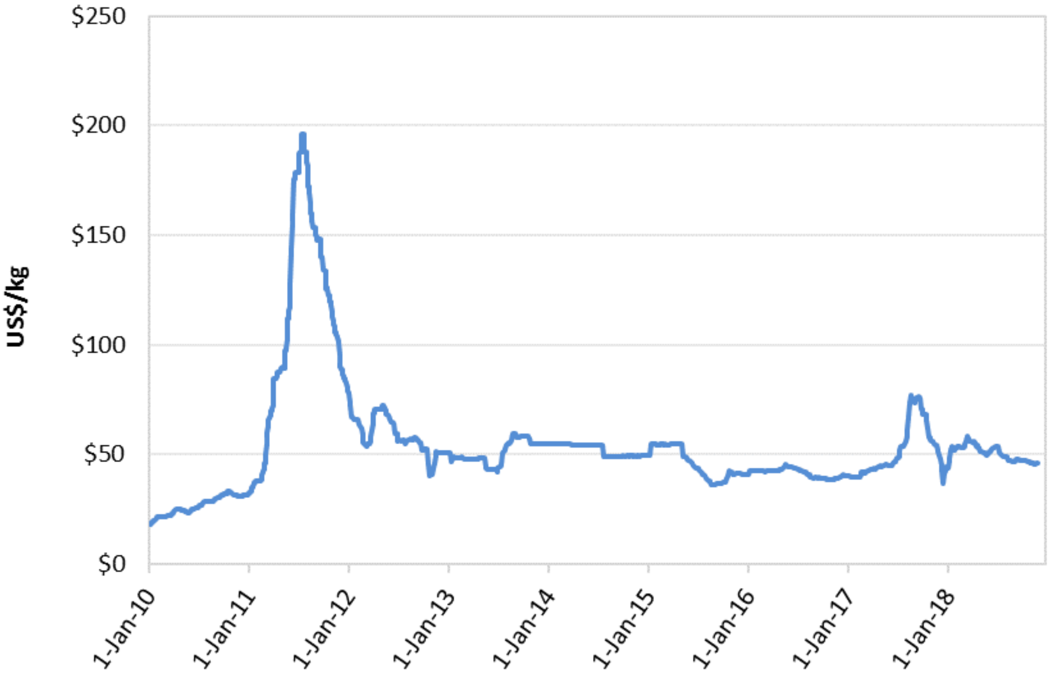
- Acid exports are expected to decline to 2020 with North African producers balancing traded phosphoric acid with internal use.

14.3 Rare Earth Pricing and Forecast

In 2011 rare earth prices rose significantly due to a 40% reduction in Chinese export quotas, temporary suspension of rare earth shipments to Japan and strong global demand. Since then rare earth prices have showed signs of bottoming out from the depressed price environment in 2012-2016 and prices have improved since 2017. According to Asian Metal, the average NdPr oxide price in 2016 was US$39 per kg before prices increased in 2017 reaching US$78 per kg in September 2017 (Figure 31).

[5] CRU consulting, Asian Pacific Phosphoric Acid Market Study, November 2018

Figure 31
Historical NdPr Oxide Prices



Price increases in 2017 were attributed to the following market trends:

- Chinese official production quotas put in place were consumed in the first half of the year, placing pressure on supply to market in the second half of 2017.
- Illegal rare earth mining, processing and trade declined through government intervention.
- Disruption to traditional supply routes through aggressive environmental checks by inspectors.
- Increased spot market purchases from speculator activity.

Prices for NdPr oxide shifted downwards and remained volatile during 2018 with the average NdPr oxide price at US$50 per kilogram.

14.3.1 Rare Earth Price Outlook

The gradual long-term upward trend in NdPr oxide prices is likely to be driven by macroeconomic and geopolitical events, environmental cost increases and stronger global demand for NdFeB magnets. Trends to drive prices higher include:

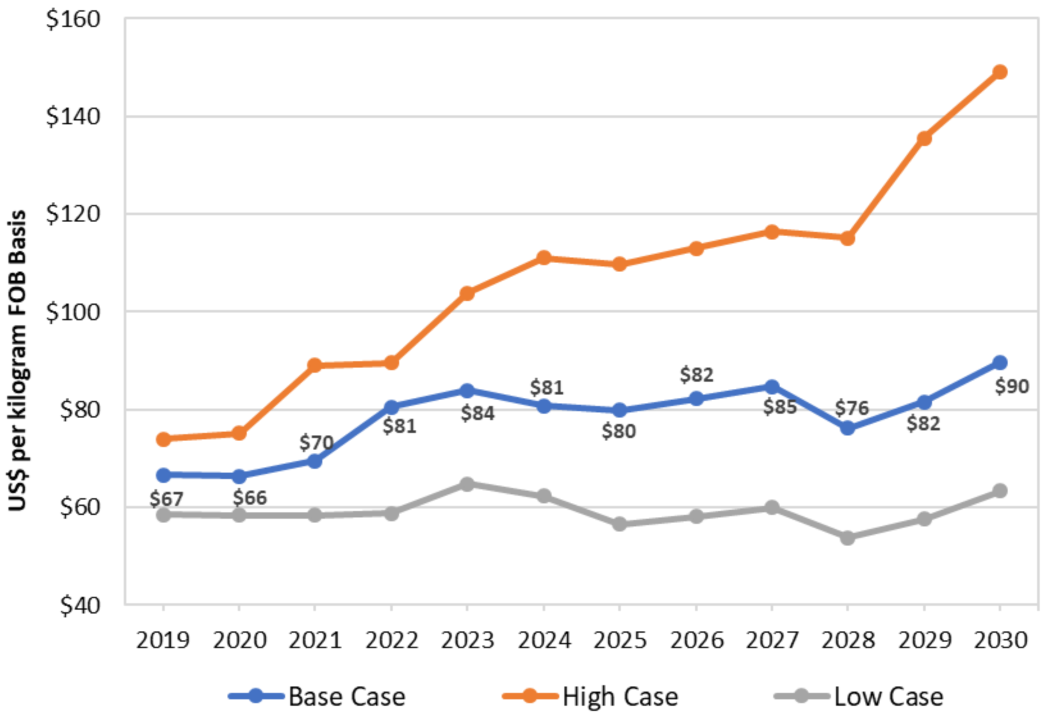
- Increased operating costs on Chinese mining and processing operations.
- Continued rising Chinese labour costs.

- Limited access to capital to expand and upgrade, constraining any new Chinese rare earth supply.
- Declining ore grades and resources.
- Overcapacity in China's rare earth supply chain and government mandates to eliminate inefficient high cost production and unsustainable operations.
- Further closure of illegal mining and processing.

Arafura commissioned an independent report from Roskill Consulting Group for in-depth market supply demand analysis and price forecasts. The long-term price forecast outlined in Roskill's report has been adopted as the basis for pricing assumptions for the DFS.

Based on Roskill's analysis, prices are expected to increase in the short-term as more EV and hybrid vehicles are introduced into the market with the baseline price for NdPr oxide is forecast to reach US$84 per kg in 2023 in real terms (Figure 32).

Figure 32
NdPr Oxide Price Forecast (Real)

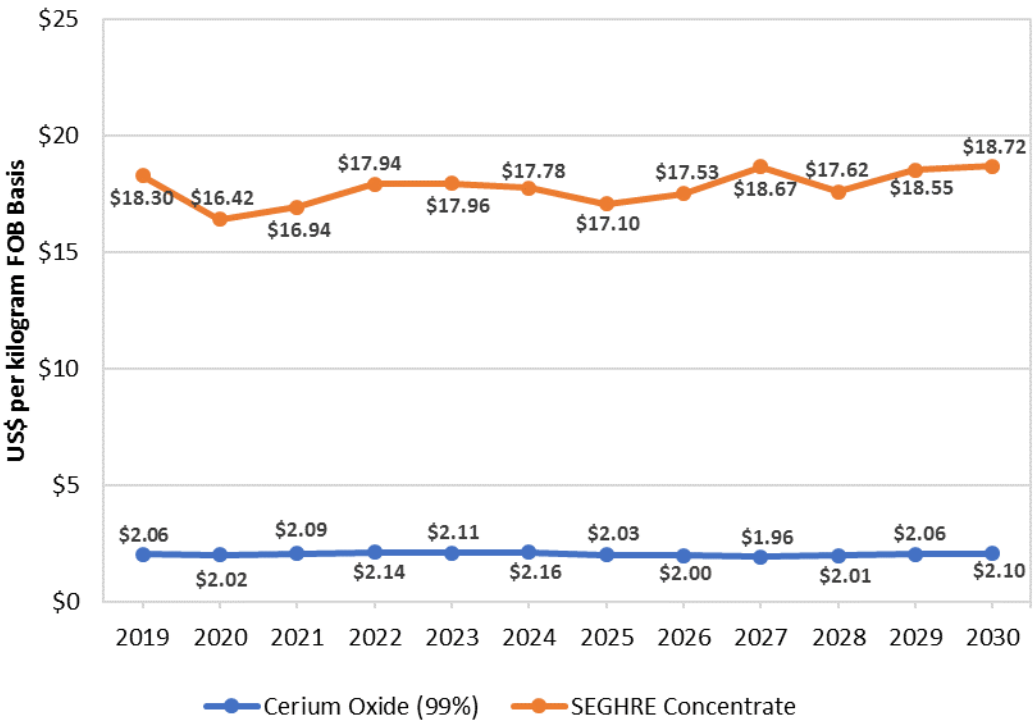


In Roskill's high case forecast scenario, prices are driven by accelerating expansion of vehicle electrification at a much faster rate than the baseline estimate and demand for NdPr oxide used in synchronous motors outstrips supply over the forecast period. Additional supply through new projects and increased Chinese production quotas are unlikely to keep up with overall demand.

In the low case scenario, slower adoption of EV and hybrid vehicles reduces overall demand, and prices are likely to remain stable, however the overall supply side of the industry would be impacted resulting in limited new production coming on stream.

Roskill also provided pricing mechanism guidance for Arafura's cerium hydroxide and SEG/HRE carbonate products. To recognize that the mixed SEG/HRE carbonate product would still undergo separation into individual REOs, an allowance of 35% realisable value of the total contained rare earth value, to allow for downstream processing cost or buyer opportunity, has been used in the DFS. Roskill's price forecasts are provided in Figure 33.

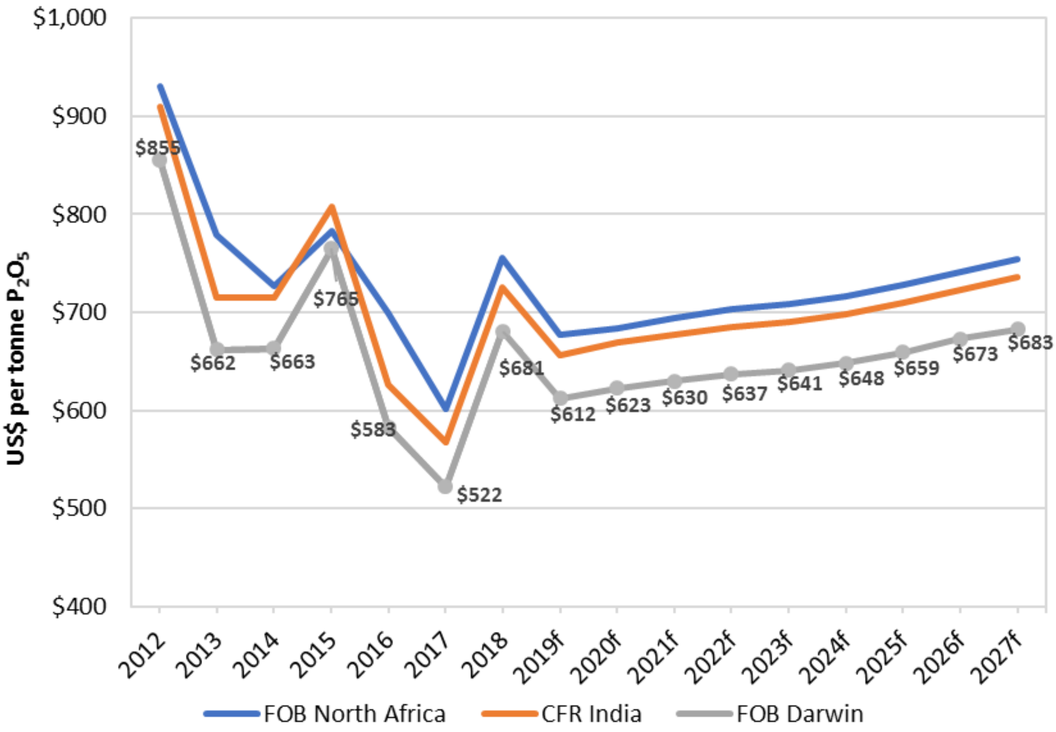
Figure 33
Cerium and SEG/HRE Product Price Forecast (Real)



14.4 Phosphoric Acid Pricing and Forecast

Phosphoric acid prices between 2012 and 2016 declined from US$909/t to US$715/t P_2O_5 due to sluggish Indian DAP demand, which is the most influential region for phosphoric acid trade. A tightening supply and demand balance in the Indian market as well as increasing Indian tariffs on US acid imports has boosted prices in 2018. CRU was engaged to provide medium and long-term phosphoric acid price projections to 2027 for the DFS with pricing provided in Figure 34.

Figure 34
Product Price Assumption (Real)



14.5 Marketing Strategy

Arafura's marketing strategy is to create and sustain value through global market positioning of high purity rare earth products to target customers supplying into key growth platforms such as hybrid and electric vehicles, clean energy technologies, factory automation, robotics and electronics.

Arafura's sales plan targets the highly lucrative Neodymium Iron Boron (NdFeB) magnet segment through the sale of NdPr oxide with future production supplying up to 7% of forecast total global NdPr demand in 2025. The sale of NdPr oxide for use in NdFeB magnets offers the most attractive growth outlook in the rare earth market and criticality of magnets used in the automotive sector strongly positions Arafura as a leading alternative supplier of NdPr oxide to China.

Arafura's sales plan includes direct sales to:

- End users across the entire rare earth supply chain including NdFeB magnet producers and leading original equipment manufacturers (OEMs) purchasing magnets.
- Distributors and large trading companies with strong local networks to end users to deliver Arafura's product to key markets.

The sales plan includes sales into regional markets of Japan, Europe and China where Arafura has actively marketed the Project and has commenced product offtake and investment discussions with key customers for its rare earth products. Sales of the flagship product NdPr oxide will primarily be a combination of sales to advanced NdFeB magnet producers in Japan and China and leading European automotive OEMs and wind turbine producers purchasing NdFeB magnets for final use in traction and wind generator motors.

In China, the Company is targeting NdPr oxide sales to several tier one NdFeB magnet producers and expects up to 50% of sales to be directed to this region. 85% of global NdFeB magnet production is in China, and supply of critical NdPr is sourced from locally produced and imported supply. Major Chinese magnet producers are expanding to meet the projected growth in the new energy vehicle (NEV) market and NdPr supply from outside of China is critical to meet the forecast demand.

Sales to Europe will primarily be NdPr oxide to automotive OEMs and wind energy companies. End users purchasing NdFeB magnets for use in synchronous motors are reducing their supply risk by directly controlling critical raw material supply and leading companies are positioning to secure NdPr oxide from alternative sources of supply outside of China for their motor applications. Traceability, visibility, and security of NdPr supply is becoming increasingly important for operators in the renewable energy and automotive sectors that are seeking to secure strategic sources of supply such as Arafura's production.

Sales to Japan are expected to be driven by NdPr oxide sales directly to NdFeB magnet producers or large trading houses for eventual use in the Japanese automotive sector. Several large Japanese trading companies control rare earth supply and are strategically securing alternative supply to China for use in Japanese industry. Supply of Arafura's NdPr oxide into Japan is an important part of the sales mix being the second largest market outside China and opportunity exists to seek product offtake and project investment.

Other rare earth products that represent less than 15% of expected rare earth revenues include cerium hydroxide and a mid to heavy mixed rare earth (SEG/HRE) carbonate will be marketed into relevant industries globally.

14.6 Customer Engagement

Arafura has established long-term relationships with prospective customers and strategic trading entities in Japan, Europe and the USA and identified a pathway to secure binding offtake agreements. The Company has for several years engaged with leading magnet and magnet alloy producers in China and Japan where 85% and 15% of NdFeB magnets are produced, respectively.

Engagement with potential customers has escalated over the past 15 months as the Company conducted its flowsheet piloting program and commenced the DFS. Following several months of discussion, Arafura entered into a non-binding offtake Memorandum of Understanding (MoU) with JingCi Material Science Co., Ltd for up to 900 tonnes of NdPr oxide NdPr production. Arafura is also engaged in discussions with several other Chinese tier one NdFeB magnet producers as part of a wider sales strategy.

The Company has for several years during project development engaged with leading Japanese NdFeB magnet producers and major trading houses. Opportunities exist to secure product offtake agreements and/or project investment arrangements with major trading companies seeking long-term NdPr oxide supply for use in drivetrain motors for the Japanese hybrid and electric vehicle market.

Arafura also has ongoing engagement with leading German OEMs, automotive and wind energy customers for NdPr oxide product offtake.

In addition to rare earth product marketing, Arafura is also engaged with several Indian fertilizer conglomerates in the public and government sectors to establish long-term partnerships to purchase 100% of the MGA phosphoric acid product. Arafura has to date executed a non-binding MoU with a major Indian fertilizer manufacturer for the sale and purchase of all of its MGA phosphoric acid product offering.

15 FINANCIAL ANALYSIS

15.1 Data and Assumptions

15.1.1 Methodology

The financial evaluation of the Project has been undertaken using a discounted cash flow (DCF) analysis in Australian dollars (A$). The evaluation includes only cash flows from the Project and excludes potential cash flows from exploration activities or other assets held by Arafura. A net present value (NPV) and internal rate of return (IRR) for the Project have been calculated over a 23-year operational period.

The following key economic assumptions apply to the base case:

- Discount rate of 10% applied to cashflows at the end of each period.
- NPV has been calculated at the Project commitment date.
- Project funding entirely through equity with no accounting for uplift that may result from any debt component of financing. However, it is likely that the Project will be at least partly funded through debt facilities.

15.1.2 Base Case Production Forecasts and Assumptions

Table 58 below sets out the key production assumptions used in the base case analysis.

Table 58
Nolans Project – Base Case Average* Production Assumption

Mine Life	Years	23
Ramp Up	Quarters	12
Ore Processed	tpa	896,000
Concentrate	tpa	293,000
TREO	tpa	13,343
NdPr Oxide	tpa	4,357
Cerium Hydroxide (REO basis)	tpa	8,383
SEG/HRE Carbonate (REO basis)	tpa	603
P_2O_5 as 54% MGA phosphoric acid	tpa	73,336

* Average production is calculated as the arithmetic annual average following the anticipated three year ramp up period and excluding the partial final year of production.

15.1.3 Capital Costs

The pre-production capital cost is estimated at A$1,006 M (US$726 M) based on the exchange rates used in the financial model. The estimate has been quoted in real terms utilising a base date as at 4Q 2018. The capital cost estimate has been prepared in the source currencies for A$, US$ and EUR, and these values have been converted to A$ using the exchange rates in Table 61.

The Project financial analysis incorporates deferred capital expenditure of A$43.7 M (US$31 M) for the construction of Modules 2 and 3 of a sulphuric acid plant. Construction of the sulphuric acid plant commences in year one of operations and is completed over nine quarters during the process plant production ramp-up.

The Project financial analysis also incorporates a deferred capital allowance for the construction of a chlor-alkali plant located at the Nolans site. Construction of the plant commences in year six of operations and production of sodium hydroxide and hydrochloric acid for use in process commences in year eight. The deferred capital estimate for the chlor-alkali plant is A$54.2 M (US$39 M).

15.1.4 Sustaining Capital

Sustaining capital costs have been included in the financial analysis for the life of the Project and has been determined and distributed across the LOM as outlined in Section 13.4. The sustaining capital cost also incorporates debottlenecking capital allowance of A$20 million in the first two years of production.

15.1.5 Operating Costs

Operating costs have been based on the DFS operating cash flow forecast estimate developed as described in Section 13.7. The DFS forecast is prepared in quarterly periods with reference to the mining and production schedule and operating cost model. The estimate has been quoted in real terms utilising a base date as at 4Q 2018. The operating cost estimate has been prepared in the source currencies for A$, US$ and EUR, and these values have been converted to A$ using the exchange rates in Table 61.

Additional operating costs have also been added for the ramp-up period to reflect additional labour, reagents, consumables and consultants required to achieve name plant process plant performance.

15.1.6 Closure Costs

Closure costs have been developed in line with the environmental approval conditions for the closure and rehabilitation of the mining area, including waste rock dumps, and the RSF. Estimated closure costs of A$ 5.1 M for the mining area and A$ 17 M for the RSF have been included in the cash flow distributed across the LOM to reflect the staged closure of the facilities.

Closure costs for the process plant and other infrastructure, such as the accommodation village, have been assumed to be offset by salvage value of the assets.

15.1.7 Working Capital

The short-term working capital requirements are determined on the basis 60 days for debtor payments and 30 days for creditors payments. Production ramp-up is also accounted for in the financial model to determine working capital requirements.

15.1.8 Revenue Assumptions

Rare earth pricing assumptions shown in Table 59 were prepared by Roskill on an FOB Darwin basis and have been derived in US$ in real terms as at 4Q 2018. Arafura has applied a 40% discount to the Roskill cerium oxide forecast to arrive at a cerium hydroxide price shown in Table 59. Price forecasts were prepared by Roskill in nominal values and have been discounted with reference to forecast United States of America consumer price index to determine real price forecasts.

Table 59 Base Case Rare Earth Price Forecast, US$/kg												
	2019	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030+**
Cerium	1.24	1.21	1.25	1.29	1.26	1.30	1.22	1.20	1.18	1.21	1.23	1.26
NdPr	66.64	66.38	69.53	80.52	83.97	80.79	79.89	82.25	84.76	76.16	81.55	89.70
SEG/HRE	6.41	5.75	5.93	6.28	6.29	6.22	5.98	6.14	6.54	6.17	6.49	6.55

Phosphoric acid price assumption for the Project has been derived in US$ and is shown in real terms as at 4Q 2018 per tonne of contained P_2O_5 in Table 60. Price forecasts were prepared by CRU and forecast on a free on board (FOB) Darwin basis.

Table 60 P_2O_5 Price Forecast Real US$ / tonne P_2O_5									
	2019	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027+**
P_2O_5	612	623	630	637	641	648	659	673	683

15.1.9 Foreign Exchange Rates

Financial modelling has been completed utilising the exchange rates set out in Table 61. These exchange rates have been sourced from Deloitte Access Economics.

Table 61 Foreign Exchange Rates					
Currency	**2019**	**2020**	**2021**	**2022**	**2023+**
US$:A$	0.709	0.726	0.721	0.712	0.704
EUR:A$	0.587	0.597	0.592	0.584	0.577

15.1.10 Taxation

The financial analysis has been prepared on the basis the Project, its operations and corporate activities are based entirely in Australia and subject to corporate tax under the *Income Tax Assessment Act 1997* at the rate of 30%. Additionally, as at 30 June 2018, Arafura has carry-forward income tax losses related to the Project of A$180 M. This loss has been offset against forecast income and income tax expense incurred for the Project.

15.1.11 Royalties

The Northern Territory *Mineral Royalty Act* (MRA) imposes royalties on minerals extracted in the Northern Territory. The Northern Territory has a hybrid mineral royalty system where the royalty payable in a royalty year is the greater of:

- 20% of the net value, with the net value being the gross production revenue less the direct operating cost of production and a capital recognition deduction.
- 2.5% of the gross production revenue.

For the Project the gross production revenue has been based on the first saleable mineral commodity which is rare earth chloride, cerium hydroxide and MGA phosphoric acid. For a rare earth chloride, Roskill has estimated realisable values for the contained rare earths at 50% for neodymium and praseodymium, 35% for samarium, terbium and dysprosium and 30% for gadolinium. Other rare earths were estimated to have no value.

15.2 Presentation of Results

An overview of the financial results for the base case is set out in Table 62 . The Project is forecast to generate average sales revenue of A$589 M (US$414 M) per annum, net of selling expenses and royalties. Total revenue will include A$539 M (US$379 M) per annum of rare earth products which will comprise approximately 90% of total revenue.

Table 62
Financial Overview

	US$ M/a*	A$ M/a*
Sales Revenue		
Rare Earth Products	379	539
Phosphoric Acid	35	50
Total Revenue (net of land transport, royalty & selling expenses)	**414**	**589**
Operating Expenditure		
Mining	30	43
Processing	103	148
General & Administration	15	21
Total Operating Expenditure	**148**	**212**
EBITDA	**266**	**377**

* Average production is calculated as the arithmetic annual average following the anticipated three year ramp up period and excluding the partial final year of production.

An overview of financial key performance indicators is set out in Table 63. After offsetting the MGA phosphoric acid by-product revenue, the Project's operating cost will be reduced to US$25.94 per kilogram of NdPr oxide.

The Project will have an NPV of A$729 M (US$497 M) at a 10% discount rate and an IRR of 17.43% on an after-tax basis, calculated over the LOM. The after-tax payback occurs in year 5 of operations. On an incentive price basis, the Project will require an NdPr oxide price of US$76 per kilogram to achieve an IRR of 15%, or US$59 per kilogram to achieve an IRR of 10%.

Table 63
KPI Analysis

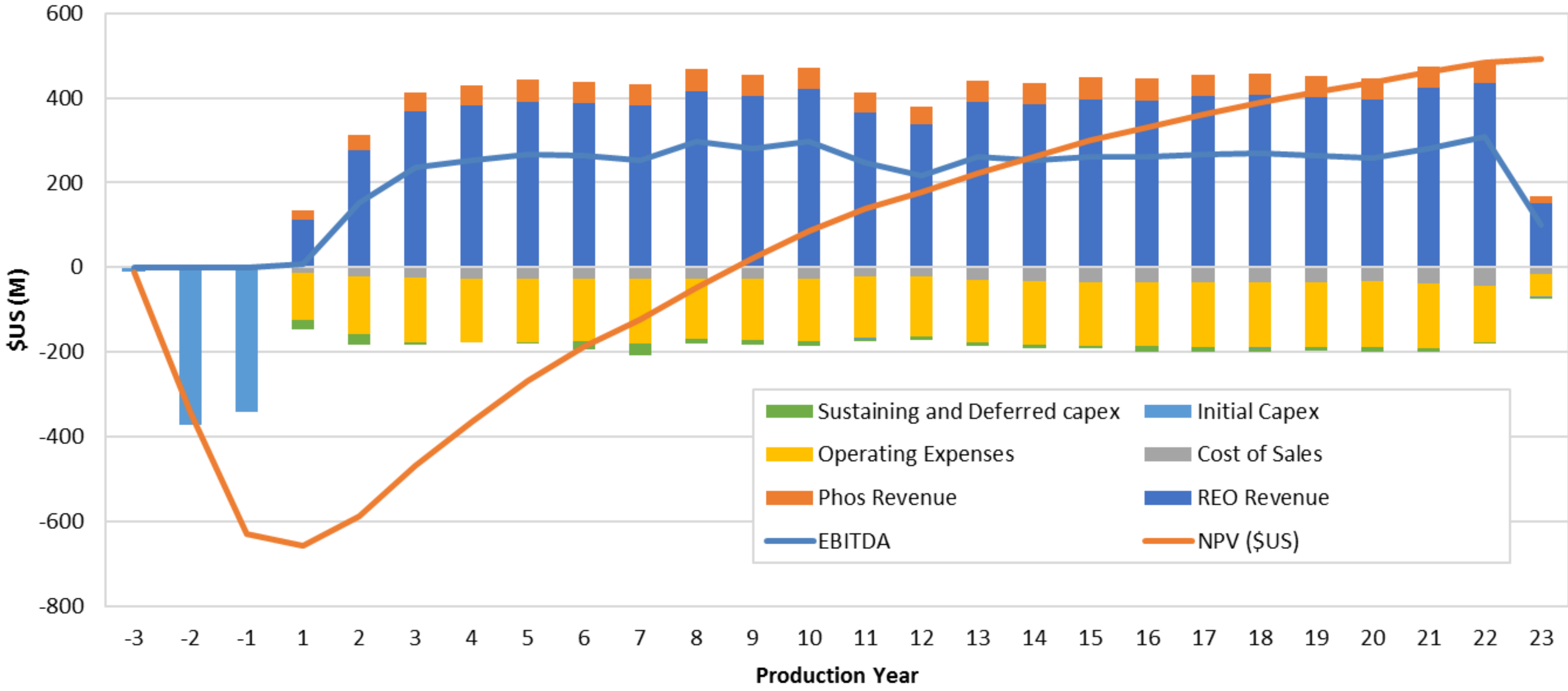
	US$	A$
Operating Cost $/kg NdPr (Average*)	34.07	48.40
Operating Cost $/kg NdPr less Phosphoric Acid by-product (Average*)	25.94	36.85
NPV_{10} after tax (million)	497	729
IRR after tax (%)	17.43%	
After tax payback	Year 5	
IRR 15% @ US$/kg NdPr	76	
IRR 10% @ US$/kg NdPr	59	

* Average production is calculated as the arithmetic annual average following the anticipated three year ramp up period and excluding the partial final year of production.

Figure 35 shows forecast EBITDA, cashflow and cumulative NPV for the life of the Project. As a result of consistent feed grade and low operating costs the EBITDA remains relatively consistent throughout the LOM. After ramp-up the average revenue to operating costs ratio ranges from 2.5 to 2.9, averaging 2.8 over this period.

Figure 35

EBITDA, NPV and Cashflows (US$)



15.3 Scenario Analysis

Several alternative configurations have been considered for the Project and the base case configuration has been selected with reference to projected financial performance and risk management assessment of the scenarios discussed below.

15.3.1 Chlor-Alkali Plant Scenarios

The scenarios examined include various timing options for the operation of the chlor-alkali plant and no chlor-alkali plant. The financial key performance indicators for the chlor-alkali plant scenarios are shown in Table 64.

Table 64
Chlor-alkali Plant Scenario Analysis

Scenario	Chlor-Alkali Plant (Year)	Operating Cost US$/kg NdPr	NPV A$ million	IRR
Base Case	8	25.94	729	17.43%
No Chlor Alkali	NA	28.87	705	17.34%
Chlor Alkali Early	4	25.11	750	17.57%
Chlor Alkali Delay	10	26.34	722	17.39%

While the early introduction of the chlor-alkali plant shows superior financial outcomes, the base case has adopted the start-up of the chlor-alkali plant in year eight since by this time the remainder of the process plant will be in stable operation and the pre-production finance will be nearing the end of the tenor period. It is worth noting that although the no chlor-alkali plant does have reduced financial outcomes the Project remains viable and competitive should this scenario be adopted.

15.3.2 Upside Case Production Schedule

The upside case production scenario which includes processing of Inferred Resources and non-preferred material types, as described in Section 3.5.4, has been assessed in the same manner as the base case. The upside production scenario has a higher NPV and IRR than the base case Table 65 which is achieved through lower unit operating costs and an increased LOM to 35 years. It cannot be assumed that Inferred Mineral Resources, due to geological uncertainty, and non-preferred material types, due to metallurgical uncertainty, will be upgraded to Ore Reserves and therefore there is no certainty that the analysis and outcomes for this scenario will be realised.

Table 65
Base- Upside Scenario Analysis

Scenario	Chlor-Alkali Plant (Year)	Operating Cost US$/kg NdPr	NPV A$ M	IRR %	Mine Life (Years)
Base Case	8	25.94	729	17.43%	23
Base- Upside	8	24.48	903	17.91%	35

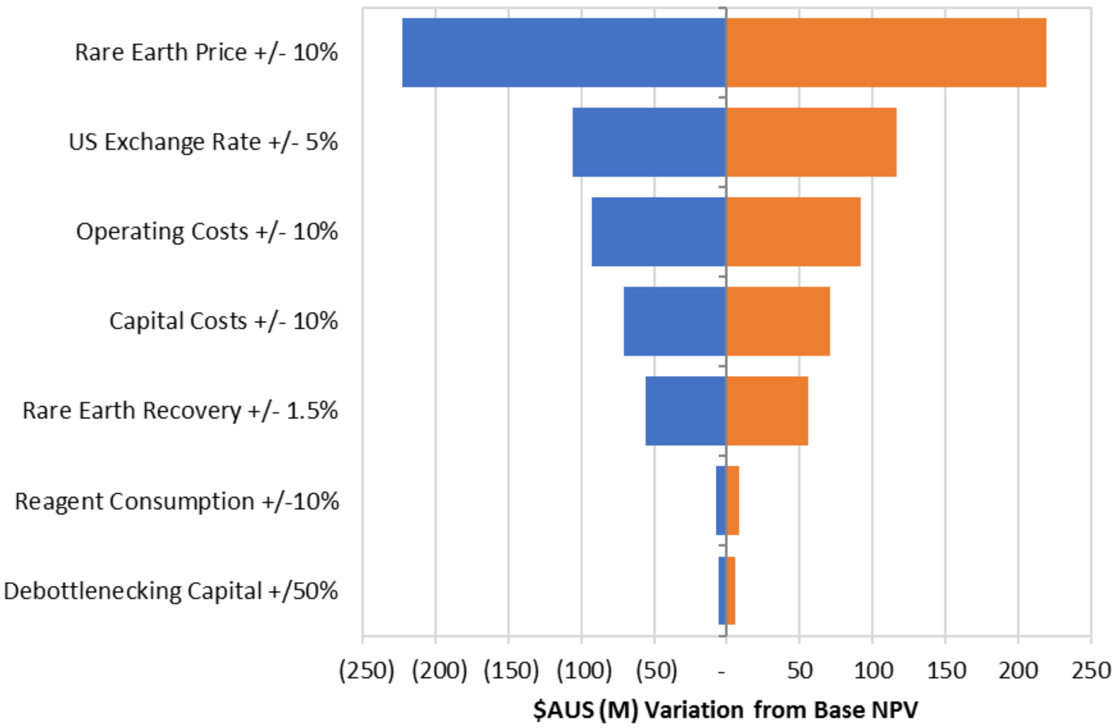
15.3.3 Lanthanum Recovery

The Project's separation plant excludes a lanthanum recovery circuit as the forecast revenue and marginal processing expense for this product shows recovery is uneconomical. The plant layout will permit the addition of the lanthanum circuit after operations commence, however there is no pre-production or deferred capital allowance in the financial analysis for this addition. Analysis shows an incentive lanthanum oxide price of US$5 per kilogram is required to support an investment decision to construct the lanthanum recovery circuit.

15.4 Sensitivity Analysis

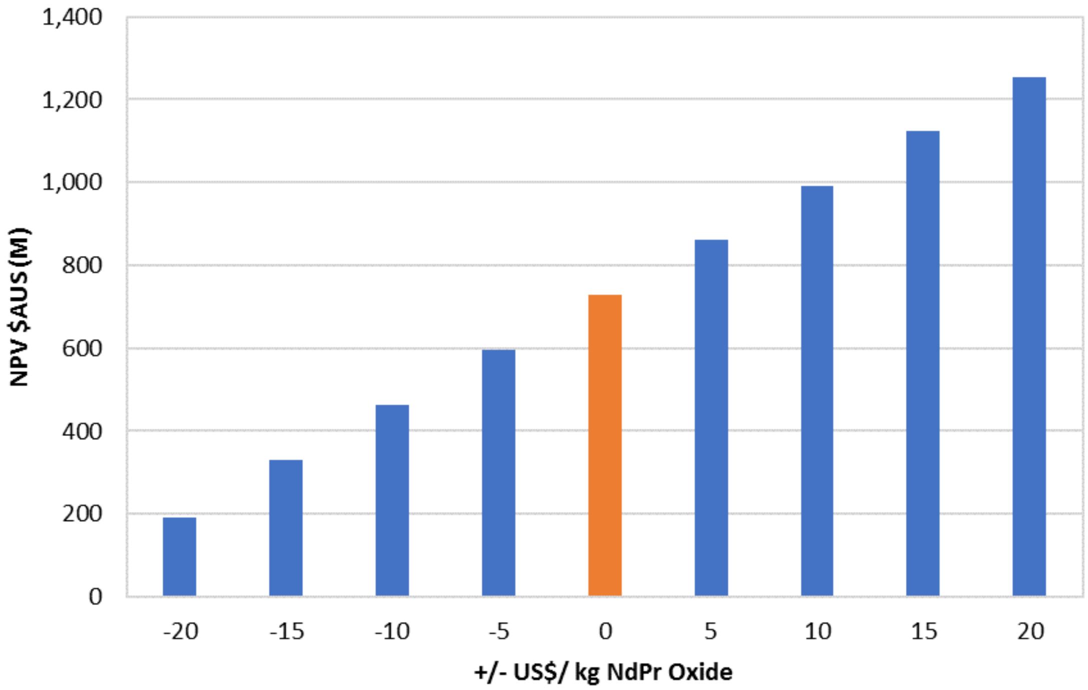
Sensitivity analysis for the base case has been carried out to demonstrate the impact and sensitivity of the financial results to changes in key assumptions and variables. The analysis in Figure 36 shows the base case is most sensitive to changes in NdPr oxide price and the US$ exchange rate. It also shows the Project is less sensitive to movements in operating and capital expenditure.

Figure 36
Key Sensitivities- Base Case NPV A$729 million



The base case assumption for the NdPr oxide selling price ranges from US$67 to US$90 per kilogram across the LOM. Sensitivity analysis shows the Project's NPV break-even (NPV_{10} = $0) price for NdPr oxide is US$60 per kilogram. The Project is highly leveraged to changes in the NdPr oxide price. Analysis shows that for every US$5 per kilogram change in the NdPr oxide price, the Project EBITDA moves by approximately A$28 M and NPV_{10} moves by approximately A$130 million (Figure 37).

Figure 37
Sensitivity Analysis – Project NPV A$ -NdPr Price Sensitivity



In addition to the base case NdPr oxide price forecast, Roskill developed a high price forecast scenario which incorporates accelerated electrification of the automotive industry and the resulting higher demand for electric motor drivetrains, but also assumes reduced demand destruction in other applications.

Table 66 sets out the real NdPr oxide price forecast for the Roskill base, high and low scenarios. The Roskill high case forecast a significant uptick in NdPr oxide prices for 2029 and 2030. A conservative revised high case NdPr oxide scenario has been prepared by Arafura, capping the NdPr oxide price at the 2028 value of US$115.10 per kilogram from 2029 onwards.

Table 66
NdPr Oxide Price Scenarios – Real US$/kg NdPr Oxide, FOB China

	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030+
Base	66.64	66.38	69.53	80.52	83.97	80.79	79.89	82.25	84.76	76.16	81.55	89.70
High	73.92	75.15	88.99	89.61	103.83	110.99	109.78	113.00	116.47	115.10	135.58	149.14
Revised	73.92	75.15	88.99	89.61	103.83	110.99	109.78	113.00	116.47	115.10	115.10	115.10
Low	58.53	58.31	58.42	58.82	64.76	62.31	56.48	58.14	59.92	53.84	57.65	63.42

Financial outcomes for the base, high, revised high and low NdPr oxide pricing scenarios are shown in Table 67. The NPV for the high case is A$1,882 M (US$1,309 M). The revised high case scenario produces an NPV of A$1,464 M (US$1,015 M). All scenarios, including the low scenario, produce strong EBITDA results.

Table 67
Pricing Scenarios – Financial Analysis

	Base A$	High A$	Revised High A$	Low $A
Sales Revenue				
Rare Earth Products	539	840	692	391
MGA Phosphoric Acid	50	50	50	50
Total Revenue (net of royalty & selling expenses)	**589**	**890**	**742**	**441**
Operating Expenditure	212	212	212	212
EBITDA	**377**	**678**	**530**	**229**
NPV_{10} after tax (million)	729	1,882	1,464	79
IRR after tax (%)	17.43	25.40	23.80	10.91

15.5 Funding Requirements

The total Project funding requirement has been calculated to be $A1,146 M (US$826 M) shown in Table 68 includes provision for capital escalation of 2.0% per annum adjusted against the proposed capital expenditure drawdown over design, construction and production ramp-up. The funding is based on 100% equity and excludes debt and other related finance costs as well as any environmental or other bonds and securities that may be payable. The total Project funding also reflects movement in values as a result of exchange rate fluctuations during the drawdown period. Working capital expenditure incorporates forecast de-bottlenecking costs.

Table 68
Project Funding

	US$M	AS$M
Pre-production Capital	726	1,006
Sulphuric Acid Plant	31	44
Working Capital	37	52
Capital Escalation	32	44
Project Funding	**826**	**1,146**

* Allowance for environmental bonds based on a preliminary assessment only with final amount agreed with DPIR as part of approval of the MMP.

15.6 Financing Structure

To execute the Project, Arafura will require total funding of $A1,146 M (excluding finance and borrowing costs) which will be sought via a combination of equity and debt finance. Arafura has commenced engagement with various parties to source project finance, production offtake and potential strategic partners to facilitate a viable funding solution for the Project. Key opportunities being pursued include:

- Engagement with potential product offtake and capital procurement partners to facilitate funding tied to Export Credit Agencies (ECAs).
- Leveraging the strategic link of NdPr oxide to NdFeB magnet production to access ECA government-backed funding and guarantees from several international jurisdictions.
- Engagement with corporate advisors and commercial banks actively involved with ECAs.
- Engagement with the Northern Australia Infrastructure Facility (NAIF) and other government sources of funding, whose mandate includes loans to infrastructure projects in northern Australia that also have an Indigenous Engagement Strategy.

The Company is also engaged with potential strategic partners and will also consider a partial Project sell down via a joint venture arrangement with an appropriate investment partner. Securing support from the right offtake party, ECA and/or a strategic partner is also a significant enabler to attract project equity at the corporate level.

16 RISK AND OPPORTUNITIES

A project risk and opportunity register was maintained and reviewed in a series of project risk workshops. Risks impacting the health and safety of personnel, the project delivery schedule and budget, the productive life of plant and equipment within it, as well as plant availability, production rate, product quality, operating and maintenance costs, were identified, assessed and ranked. A risk ranking matrix considering likelihood and consequence as well as industry experience from the workshop attendees were used to assess each risk.

Table 69 summarises the DFS risk rating outcomes following the application of the identified controls. It should be noted that no risks were identified as extreme.

Table 69
DFS Risk Rating Summary

Description	High	Moderate	Low
Risk	26	107	37
Risk and Opportunity	-	2	2

The risk and opportunities register summarises the risk or opportunity type, area of the Project, risk and event definition, existing controls in place to mitigate the risk, risk rating and new controls, if required to further lower the risk rating.

The following high risks, along with their controls, were identified:

- Radiation exposure. Personnel working at the mine and in parts of the process plant are at risk of exposure to NORM material. This is controlled through an appropriate MMP and radiation management plan and engagement of suitably experienced consultants to advise on appropriate controls.

- Mining. The open-pit mining operation risks consist of waste dump wall failure, pit ramp failure, interaction between equipment and pedestrians, interaction between heavy and light vehicles, blasting activities and falling objects. This is controlled through the typical mining practices of establishing appropriate operations procedures, a rigorous mining contract tendering process, and application of the mine safety legislation.

- Residue storage facility. Effluent streams are stored in a wet RSF, which if incorrectly designed, constructed or operated can lead to solution seepage into groundwater or overtopping leading to erosion and dam wall failure, which may result in personnel or environmental exposure to NORM material. Implementing preliminary design and operating procedures identified in the DFS, along with appropriate peer review, as well as establishing monitoring procedures during construction and operation, will be important to mitigate the risks associated with the RSF.

- Sulphation materials handling. There is a risk of blockages in equipment due to the material handling characteristics of the sulphated material. Test work and pilot plant campaigns have been performed and their results incorporated into the current design. This risk is to be controlled by further discussion with vendors in the next phase of engineering, additional test work, and implementation of the lessons learned during the pilot test work program.

- Phosphoric acid quality. In order to produce MGA phosphoric acid, thorium and uranium must be removed from the acid stream prior to concentration. The current design utilises IX, however only preliminary test work has been carried out to date. Further test work is required to confirm the design and operating characteristics of the current IX flowsheet.

- Precipitation agent recovery. The recovery and concentration of the precipitation agent impacts on the efficiency of the process and operating costs. Whilst recovery from normal aqueous solutions is well understood, recovery from a highly acidic solution has not been fully demonstrated to date and further vendor testing is required to enable detailed design.

- Cerium product. Cerium hydroxide is currently separated from the other rare earths by selective dissolution with hydrochloric acid. The quality of the cerium product and losses of NdPr oxide to the cerium product in filtration stage is largely impacted by the chemistry and filtration characteristics of the material. Whilst the pilot plant test work has been completed full analysis of the results and incorporation into the design will be required to finalise the design and operating parameters of this aspect of the process.

- Logistics. Dangerous goods, including acids, alkalis and flammable materials, are transported by truck or rail which will pass through Alice Springs and may lead to safety concerns for members of the public, particularly should an incident occur. Appropriate logistics plan, public engagement with stakeholders and selection of an appropriately experienced logistics contractor will minimise these risks.

Additional to these risks, there are various opportunities to optimise the Project performance, including:

- Optimisation of the energy strategy, particularly around the use of various vapour recompression mechanisms in evaporators, offers the opportunity to reduce energy costs for the Project.

- Trucking of ore 24 hours per day from the mine to the process plant may decrease the size and cost of the crushing circuit.

- Rationalisation of the process plant layout may offer reductions in capital cost.

- Partnering with reagent manufacturers or other consumers, existing or potential, may offer the opportunity to reduce hydrochloric acid and sodium hydroxide costs without the construction of a chlor-alkali plant at site or in Darwin or Adelaide.

- Developing processing solutions for the non-PAPLP material types offers the opportunity to reduce mining rates and costs, and improve process recovery.

Glossary	
AGP	Amadeus gas pipeline
Allanite	Silicate mineral that may contain up to 30% REO
ALS	ALS Ammtec
AMC	AMC Consultants Pty Ltd
ANCOLD	Australian National Committee on Large Dams
ANSTO	Australian Nuclear Science and Technology Organisation
Apatite	Phosphate mineral that may contain up to 30% REO, also Fluorapatite
Arafura or the Company	Arafura Resources Limited
ASX	Australian Stock Exchange
BOO	Build Own Operate
CA	Chlor-alkali
CAGR	Compound Annual Growth Rate
CLC	Central Land Council
CRM	Certified Reference Materials
CRU	CRU International Pty Ltd
DAP	Di-ammonium Phosphate
DCF	Discounted Cash Flow
DFS	Definitive Feasibility Study
DoEE	Department of Environment and Energy
DPIR	Department of Primary Industry and Resources
EA Act	Northern Territory Environmental Assessment Act 1982
ECI	Early Contractor Involvement
EIS	Environmental Impact Statement
EL	Exploration Licence
EPBC Act	Environment Protection Biodiversity Conservation Act
EPC	Engineer, Procurement and Construction
EPCM	Engineering, Procurement and Construction Management
ERP	Enterprise Resource Planning
FIFO	Fly-in/Fly-out
GDE	Groundwater Dependent Ecosystem
GHD	GHD Pty Ltd
GJ	Gigajoule
Hatch	Hatch Pty Limited
HCl	Hydrochloric Acid
HDPE	High Density Polyethylene
HRE	Heavy Rare Earths
HV	High Voltage
ILUA	Indigenous Land Use Agreement
IX	Ion Exchange
Knight Piésold	Knight Piésold Consulting
kWh	Kilowatt Hour

Glossary	
LOM	Life of Mine
MGA	Merchant Grade Acid
Mining Plus	Mining Plus Pty Ltd
ML	Mineral Lease
MMP	Mining Management Plan
Monazite	Phosphate mineral that may contain up to 70% REO
MTA	Mineral Titles Act
MTO	Material Take Off
NdFeB	Neodymium Iron Boron Magnet
NdPr, NdPr Oxide	Neodymium and Praseodymium mixed oxide
NEV	New Energy Vehicles
NGO	Non-government Organisation
NORM	Naturally Occurring Radioactive Material
NPK Fertilizer	Nitrogen, Phosphorous and Potassium Fertilizer
NP1	Non PAPL Preferred Material Type 1 (abundant with Fe Oxides)
NP2	Non PAPL Preferred Material Type 2 (significant allanite/epidote)
NTCAT	Northern Territory Civil and Administrative Tribunal
NT EPA	Northern Territory Environment Protection Authority
OK	Ordinary Kriging
P&ID	Piping and Instrumentation Diagram
PAII	Phosphoric Acid Implication Ratio
PAPL	Phosphoric Acid Pre-Leach
PAPLP	PAPL Preferred
PFS	Prefeasibility Study
PLR	Pre-Leach Residue
Project	Nolans Project
QAQC	Quality Assurance and Quality Control
QRA	Quantitative Risk Assessment
Qube	Qube Bulk Ptd Ltd
RAB	Rotary Air Blast
RC	Reverse Circulation
REE	Rare Earth Element
RL	Relative Level
ROM	Run of Mine
Roskill	Roskill Consulting Group Limited
RSF	Residue Storage Facility
SAG	Semi-Autogenous Grinding
SAP	Sulphuric Acid Plant
SAPL-DSP	Sulphuric Acid Pre-Leach, Double Sulphate Precipitation
SEG	Samarium-Europium-Gadolinium
SG	Specific Gravity
SGS	SGS Australia Pty Ltd

Glossary	
Simulus	Simulus Pty Ltd
SX	Solvent Extraction
TREO	Total Rare Earth Oxide
WBS	Work Breakdown Structure