Sheffield Resources LIMITED

Thunderbird Mineral Sands Project

Public Environmental Review

EPA Assessment No. 2073

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MBS ENVIRONMENTAL

THUNDERBIRD MINERAL SANDS PROJECT
PUBLIC ENVIRONMENTAL REVIEW

Distribution List:

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Invitation to Make a Submission

The Environmental Protection Authority (EPA) invites people to make a submission on this proposal. Electronic submissions are preferred.

Sheffield Resources Limited proposes to develop the Thunderbird Mineral Sands Project. In accordance with the *Environmental Protection Act 1986* (*EP Act*), a Public Environmental Review (PER) has been prepared which describes this proposal and its likely effects on the environment. The PER is available for a public review period of 4 weeks from 16/01/2017 closing on 13/02/2017.

Comments from government agencies and from the public will help the EPA to prepare an assessment report in which it will make recommendations to government.

Where to get copies of this document

Electronic and hard copies may be obtained from:

Mr Bruce McFadzean
Sheffield Resources Ltd
Level 2, 41 - 47 Colin Street
West Perth WA 6005
Telephone: (08) 6424-8440
Email: info@sheffieldresources.com.au

Electronic copies may also be obtained through the proponent's website: www.sheffieldresources.com.au.

Why write a submission?

A submission is a way to provide information, express your opinion and put forward your suggested course of action – including any alternative approach. It is useful if you indicate any suggestions you have to improve the proposal.

All submissions received by the EPA will be acknowledged. Submissions will be treated as public documents unless provided and received in confidence, subject to the requirements of the *Freedom of Information Act 1992* (*FOI Act*), and may be quoted in full of in part in the EPA's report.

Why not join a group?

If you prefer not to write your own comments, it may be worthwhile joining a group interested in making a submission on similar issues. Joint submissions may help to reduce the workload for an individual or group, as well as increase the pool of ideas and information. If you form a small group (up to 10 people) please indicate all the names of the participants. If your group is larger, please indicate how many people your submission represents.

Developing a submission

You may agree or disagree with, or comment on, the general issues discussed in the PER or the specific proposal. It helps if you give reasons for your conclusions, supported by relevant data. You may make an important contribution by suggesting ways to make the proposal more environmentally acceptable.

When making comments on specific elements on the PER:

- Clearly state your point of view.
- Indicate the source of your information or argument if this is applicable.
- Suggest recommendations, safeguards or alternatives.

Points to keep in mind

By keeping the following points in mind, you will make it easier for your submission to be analysed:

- Attempt to list points so that issues raised are clear. A summary of your submission is helpful.
- Refer each point to the appropriate section, chapter or recommendation in the PER.
- If you discuss different sections of the PER, keep them distinct and separate, so that there is no confusion as to which section you are considering.
- Attach any factual information you may wish to provide and give details of the source. Make sure your information is accurate.

Remember to include:

- Your name.
- Address.
- Date.
- Whether and the reason why you want your submission to be confidential.

Information on submissions will be deemed public information unless a request for confidentiality of the submission is made in writing and accepted by the EPA. As a result, a copy of each submission will be provided to the proponent but the identity of private individuals will remain confidential to the EPA.

The closing date for submissions is 13/02/2017.

The EPA prefers submissions on PER documents to be made electronically on its consultation hub at https://consultation.epa.wa.gov.au.

Alternatively, submissions can be:

- Posted to: Chairman, Environmental Protection Authority, Locked Bag 10, EAST PERTH WA 6892, Attention: Christopher Stanley.
- Delivered to the Environmental Protection Authority, Level 8, The Atrium, 168 St Georges Terrace, Perth, Attention: Christopher Stanley.

If you have any questions on how to make a submission, please ring the Office of the Environmental Protection Authority on 6145 0800.

PREFACE

Sheffield Resources acknowledges and respects the Traditional Owners, both past and present, for the lands where the Thunderbird Mineral Sands Project is to be located.

This Public Environmental Review document contains both scientific and technical information about the impacts and controls which are proposed to take place at Thunderbird.

Sheffield Resources will be respectful and mindful that the operations will also impact on the Traditional Owners, in particular their "Seasonal Calendar" and when they access country for their traditional foods and medicines. Sheffield Resources will place great importance in the preservation and education of this unique "Way of Life" and culture.

EXECUTIVE SUMMARY

Sheffield Resources Limited proposes to undertake mining of mineral sands for more than 40 years from the Thunderbird deposit; a greenfield site in the Kimberley region of Western Australia. The mineral sands products will be transported to the towns of Derby and Broome, and exported through their respective Ports.

This document is a Public Environmental Review (PER) of the impacts of the project, prepared in accordance with Part IV of the *Environmental Protection Act 1986* (WA) (*EP Act*). It also fulfils the impact assessment requirements of the *Environment Protection and Biodiversity Conservation Act 1999* (Cth) (*EPBC Act*), as it is being assessed under the Bilateral Agreement between the Commonwealth of Australia and the State of Western Australia, made under section 45 of that Act.

PROJECT OVERVIEW

The project will involve:

- Mining of heavy mineral sands for more than 40 years from the Thunderbird deposit.
- Onsite primary and secondary processing of ore to produce a range of saleable mineral sands products.
- Abstraction and reinjection of groundwater to allow mining and supply ore processing needs.
- Development of infrastructure to support the project.
- Upgrade and extension of an existing pastoral road to form a 30 km Site Access Road.
- Transport of mineral sands products to Derby and Broome Ports for storage prior to export.
- Export of bulk mineral sands products from Derby Port via King Sound and packaged mineral product from Port of Broome to international customers.

Construction of the project is scheduled to commence in Quarter 3 2017, with mining and production scheduled to commence in early 2019. The project will be fully operational in early 2019 with the first export of product anticipated by end of 2019.

JUSTIFICATION FOR THE PROJECT

The objective of the project is to establish an operating mineral sands mine and processing facilities with supporting infrastructure and services for production and export of heavy mineral sands products including ilmenite, primary zircon, zircon concentrate, titano-magnetite and HiTi88 Leucoxene. This is driven by worldwide need for ceramics, paint and other commonly used materials that contain these products.

The project represents an opportunity for Western Australia to benefit from the development of this resource, which will have a positive impact on the Kimberley region over an extended period. The project will create employment opportunities for local Indigenous and non-Indigenous people, and create opportunities for local Indigenous and non-Indigenous businesses. The project will also add to scientific knowledge through ongoing monitoring of the environment. The project will augment Western Australia's mineral sands exports which have begun to decline due to the maturing of mineral sands operations in the Perth Basin.

KEY CHARACTERISTICS

A summary of the key physical and operational characteristics of the project is presented below:

Summary of the Proposal	
Proposal Title	Thunderbird Mineral Sands Project
Proponent Name	Sheffield Resources Limited
Short Description	The project is located approximately 95 km northeast of Broome and 75 km west of Derby in Western Australia. The project includes heavy mineral sands mining above and below the water table, dewatering within the Broome Sandstone Aquifer, onsite mineral processing, transport of bulk mineral sands products to Derby Port and transhipping via King Sound using new and existing infrastructure at Derby Port and transport of packaged products to the Port of Broome for export using existing infrastructure. The project includes: • Mining up to a depth of approximately 100 m below ground level (near the end of mine life). • Processing of heavy mineral sands including use of a tailings storage facility. • Progressive backfilling of the mine pit and rehabilitation of backfilled areas. • Upgrade and extension of an existing road, and construction of a new road, to provide an approximately 30 km long Site Access Road linking the project to the Great Northern Highway. • Groundwater abstraction from the Broome Sandstone Aquifer. • Supporting infrastructure including internal roadways, accommodation village, power plant, workshops, offices and landfill. • Storage and export of bulk mineral sands products from Derby Port and export of packaged products from the Port of Broome.

Physical Aspects		
Aspect	**Location**	**Proposed Extent Authorised**
Mine Site Development Envelope		
Mining excavation	Figure 6	Progressive clearing and mining of no more than 1,635 ha within a 5,875 ha Development Envelope over a 40+ year timeframe. Approximately 200 ha of mine pit open at any one time, with progressive backfilling and rehabilitation.
Processing Infrastructure	Figure 12	Clearing of no more than 40 ha within a 5,875 ha Development Envelope.
Borefield	Figure 4	Clearing of no more than 15 ha within a 5,875 ha Development Envelope.
Tailing Storage Facility	Figure 4	Clearing of no more than 110 ha within a 5,875 ha Development Envelope.
Other Supporting Infrastructure	Figure 4	Clearing of no more than 320 ha within a 5,875 ha Development Envelope.
Site Access Road	Figure 4	Clearing of no more than 160 ha within a 5,875 ha Development Envelope.
Port Development Envelope		
Storage/Export Facility	Figure 15	Construction of port storage/export facility on existing disturbed port land.

Operational Aspects		
Element	**Location**	**Proposed Extent**
Mineral Sands Processing	Figure 12	• 0 – 5 years: initial tailings deposition in tailings storage facility at 7.5 Mtpa. • 1 year - 5 years: tailings deposition in mine pit at 7.5 Mtpa. • 5 years - life of mine: waste and tailings backfilled to mine pit at 15 Mtpa.
Abstraction of Groundwater	Figure 4	• Borefield abstraction up to 13 GL per annum for Mine Site use during commissioning. • Mine Dewatering abstraction up to 33 GL per annum after commencement of mining below the watertable. • Groundwater reinjection up to 22 GL per annum after commencement of mining below the watertable.
Power	Figure 4	• 35 MW multifuel (gas and/or diesel) power plant.
Transport, Storage at Port and Shipping of Product	Figure 14 Figure 16	• Bulk product transport by road train to Derby Port via Site Access Road and Great Northern Highway (approximately 145 km total). • Storage of up to 50,000 t of mineral sands products in an enclosed facility at Derby Port. • Transhipment of bulk mineral sands products via barges from Derby Port to ships anchored at existing sea transfer point at Point Torment. Possibility of using other commercial export options currently under consideration by third parties including use of a lock system. • 20 – 40 sailings/annum from Derby Port depending on ship size. • Storage of up to 10,000 t of packaged products at the Port of Broome. • 20 – 30 sailings/annum from the Port of Broome depending on customer orders.

Stakeholder Consultation
Sheffield has, and will continue to, undertake a vigorous and proactive communication, engagement and consultation program with its stakeholders, government and the broader West Kimberley community. Sheffield engaged stakeholders early in the planning process, primarily in the interests of achieving a collaborative approach and to ensure that local knowledge is considered in the design and management of Thunderbird Mineral Sands Project.

Stakeholder consultation commenced in 2014 with the introduction of the project to the Traditional Owner groups. This consultation was enhanced throughout the exploration phase of the project; the function was strengthened with the appointment of a Community Relations Advisor and remains an integral part of the current project development phase.

Key Preliminary Environmental Factors
Key environmental factors for the Mine Site Development Envelope comprise the following:

- Flora and Vegetation.
- Terrestrial Fauna.
- Hydrological Processes.
- Inland Waters Environmental Quality.
- Heritage.

Key environmental factors for the Port Development Envelope comprise the following:

- Marine Environmental Quality.
- Amenity.

Other Preliminary Environmental Factors
Other relevant environmental factors for the Mine Site Development Envelope comprise the following:

- Landforms.
- Subterranean Fauna.
- Terrestrial Environmental Quality.
- Air Quality and Atmospheric Gases.
- Human Health.

Other relevant environmental factors for the Derby Port Development Envelope comprise the following:

- Benthic Communities and Habitat.
- Marine Fauna.
- Terrestrial Environmental Quality.
- Human Health.
- Hydrological Processes.

Integrating Environmental Factors
Integrating environmental factors for the Mine Site Development Envelope comprise the following:

- Rehabilitation and Decommissioning.
- Offsets.

Sheffield has completed a range of environmental investigations in order establish baseline conditions as a basis to characterise the potential environmental impacts of the project.

Impact Assessment
The approach used to assess potential impacts from the project is based on determining the likelihood and consequence following exposure to stressor/s. A number of aspects were considered in determining the consequence of each potential impact, including:

- Type of impact (direct or indirect).
- Geographic extent, size and scale.
- Duration, frequency, reversibility of the potential impact.
- Whether the potential impacts are from planned or unplanned events.
- Sensitivity of the receptor/resource and the value of the receptor/resource and whether impacts are likely to be from planned or unplanned events.

Likelihood is the probability of a stressor impacting on an environmental factor, after the application of mitigation and management measures. Where practicable, likelihood was quantified based on quantitative information or data.

The residual impacts were determined by assessing the likelihood and consequence when mitigation and management measures are applied.

Each of the potential impacts has been assessed, and assigned a residual impact based on the consequences and likelihood of occurrence of the impact. Mitigation and management measures have been developed following a hierarchy of controls:

- **Avoidance**: Significant avoidance and minimisation measures have been incorporated into decision making and Mine Site design.
- **Minimisation**: Measures that minimise an impact (for example by storing hydrocarbons in impermeable storage areas).
- **Reduction**: Measures that reduce or eliminate the impact of an activity (for example implementing measures to reduce dust emissions from vehicle travel on unsealed roads).
- **Correction**: Measures that correct or rectify an impact (for example via restoration, repair or rehabilitation).
- **Compensation**: Measures to compensate for impacts from project activities (for example by replacing lost or damaged environmental components in kind or with agreed substitute resources).

Offsets

After application of the mitigation hierarchy, Sheffield considers that the project will have a significant residual impact on only one Key Environmental Factor – Terrestrial Fauna. Specifically the residual impacts are to the Greater Bilby, which is also a Matter of National Environmental Significance. The Greater Bilby is listed as Vulnerable under the *WC Act* and the *EPBC Act*.

Sheffield proposes an offsets package to mitigate the residual impacts of clearing 639.6 ha of Greater Bilby habitat through establishment of the Kimberley Greater Bilby Trust to facilitate research into and conservation programs for the benefit of the Greater Bilby as well as providing direct logistical support for people undertaking research programs relevant to the Greater Bilby.

ENVIRONMENTAL ACCEPTABILITY

This PER provides an assessment of the potential impacts to the environment from the project. Sheffield is confident that the project can be undertaken in such a way as to meet the Environmental Protection Authority objectives for Key Environmental Factors, Other Environmental Factors, and Integrating Factors. Mitigation and management measures have been applied to minimise the residual environmental impact of the project, and an offset strategy has been proposed to provide additional mitigation to project residual impacts.

Sheffield considers that the potential impacts to the environment will be able to be adequately managed such that the EPA environmental objectives will be met, and that the residual impacts are therefore acceptable.

Factor	EPA Objective	Existing Environment	Potential Impact	Management Measures	Predicted Outcomes
Key Environmental Factors – Mine Site Development Envelope					
Flora and Vegetation	*To maintain representation, diversity, viability and ecological function at the species, population and community level.*	A total of 255 vascular plant taxa, representative of 129 genera and 44 families were recorded in the survey area (the survey area was larger than the Mine Site Development Envelope). No Threatened flora pursuant to Schedule 1 of the *Wildlife Conservation Act 1950* or *Environment Protection and Biodiversity Conservation Act 1999* were recorded within the Mine Site Development Envelope. Two Priority taxa were recorded within the flora survey area by Mattiske, *Triodia caelestialis* (P3) and *Pterocaulon intermedium* (P3). A total of 15 vegetation communities were defined and mapped. Two of the pindan vegetation communities accounted for approximately 86% of the surveyed area and were considered the most representative of the Mine Site Development Envelope. The other main communities mapped were associated with the drainage channels and rocky hills. Potential GDEs have been inferred within the project area and wider region. (Mattiske 2016b; Rockwater 2016)	Direct clearing impacts: • Loss of native vegetation communities • Loss of conservation significant flora. Indirect impacts: • Dust generated from mining activities resulting in reduced vegetation health and condition • Increased presence and health of weeds resulting in reduced native vegetation cover and diversity. • Modification of surface water flows resulting in loss, or reduced health and condition, of native vegetation. • Groundwater abstraction resulting in loss or reduced health and condition of groundwater dependent ecosystems. • Altered fire regime resulting in loss, or reduced health and condition, of native vegetation. *Note: groundwater dependent ecosystems are discussed in the groundwater impacts section.*	• Land disturbance will be kept to the minimum necessary for development of the project. • Existing disturbed areas will be used wherever possible to minimise total ground disturbance. • Land clearing will be undertaking progressively with the amount of active disturbance minimised. • Ground disturbance procedures and a permitting system will be implemented. • Progressive rehabilitation will be undertaken on disturbed areas as they become available. • Monitoring of analogue and rehabilitated areas will be undertaken to ensure short, medium and long-term rehabilitation objectives are achieved. Monitoring will be carried out on a regular basis to assess the success of revegetation in rehabilitated areas. • Ongoing development of monitoring methodology and rehabilitation techniques will occur during the life of the project. Further assessments over time will plot the development of rehabilitated areas against analogue sites and progression towards completion targets. • Topsoil and vegetation (including woody debris) will be respread over rehabilitated areas to act as a seed source and to protect the soil from erosion. • Local provenance seed and propagated material will be used, if required, to rehabilitate disturbed areas • The site induction program will provide information on protection of vegetation and ground disturbance authorisation procedures. • Vehicles and mining equipment will keep to designated roads. • Dust suppression will be carried out during construction, operation and closure. • A weed hygiene system will be developed and implemented in consultation with the pastoralist. • Weed inspections will be conducted following significant rainfall, and depending on results, appropriate management actions will be implemented if required. • Firefighting equipment will be located on site and emergency personnel will be trained in fire response • Lightning protection equipment will be installed as part of project design where necessary. • Vehicles will not be permitted to leave access tracks or cleared areas. • A Hot Work Permit system will be developed and implemented. • All machinery and vehicles undertaking clearing activities will be fitted with firefighting equipment. • Sheffield will work with the pastoralist, Traditional Owners and DFES to undertake prescribed burns and install and maintain firebreaks if required so that potential environmental damage from extreme and out of control wildfires is minimised and infrastructure and the community are protected throughout the life of the project. • The project site induction will include information on the prevention and management of fires. • Rehabilitated areas will be monitored to ensure radiation levels are within environmental screening criteria (10 µGy/h) or established pre-mining background levels.	Clearing will result in the loss of vegetation however the majority of clearing (86%) is of communities that are common and widespread and all vegetation communities are represented outside the clearing footprint. Furthermore, the main clearing area is for the Mine Site Area, which will be progressively cleared and rehabilitated, therefore maintaining representation and diversity in the wider area as impacts will be short to medium term. It is recognised that individuals of Priority listed species *Triodia caelestialis* (P3) and *Pterocaulon intermedium* (P3) will be impacted as a result of the proposal, however these taxa are considered to be widespread within the wider environment and are not restricted to the Mine Site Development Envelope. Whilst the Priority flora that Ecologia have recorded could not be substantiated by Mattiske, impacts are not expected to be significant. Dust, increased presence of weeds, modification of surface water flows, fire regimes and radiation exposure may affect flora and vegetation; however these impacts will result in localised and incidental effects on the health, abundance and structure of vegetation communities, all of which are well represented in the region. Sheffield considers that the potential impacts to flora and vegetation will be able to be adequately managed such that the environmental objective for flora and vegetation will be met.

Factor	EPA Objective	Existing Environment	Potential Impact	Management Measures	Predicted Outcomes
Terrestrial Fauna	*To maintain representation, diversity, viability and ecological function at the species, population and assemblage level.*	Fauna surveys recorded a total of 20 mammals, 118 birds, 44 reptiles and 8 amphibians occurring within the Mine Site Development Envelope or surrounding areas. Of note was an approximate 80 km range extension of *Lerista apoda* (Dampier Land Limbless Slider) from coastal areas of the west coast of the Dampier Peninsula. Nine conservation significant fauna species were recorded within the wider survey area, however, only three were recorded within the Mine Site Development. These were the Greater Bilby, the Short-tailed Mouse, and the Rainbow Bee-eater. (Ecologia 2012a, 2014a, 2015)	• Fragmentation of vertebrate fauna habitat resulting in displacement of fauna. • Habitat clearing causing disturbance of conservation significant fauna species. • Loss of SRE fauna habitat resulting in loss of SRE. • Vehicle strike causing injury or death of native fauna. • Increase in pest species impacting native fauna. • Altered fire regime impacting native fauna. • Light and noise pollution disrupting native fauna. • Fauna entrapment leading to injury or death.	• Clearing activities will be managed to ensure clearing is strictly limited to that necessary for operations. • Land clearing will be undertaking progressively with the amount of active disturbance minimised. • Disturbed areas will be rehabilitated as they become available. • Topsoil and vegetation will be respread over rehabilitated areas to act as a seed source and mulch to protect the soil from erosion and provide habitat for fauna. • Significant trees (especially those with hollows) will be retained where practicable. • Speed limits will be implemented for operational areas and the Site Access Road in order to minimise the risk of fauna injury or mortality from vehicle strike. • Personnel will be required to adhere to speed limits and drive to road/weather conditions to minimise risks of fauna injuries or death due to vehicle traffic • The Site Access Road will be constructed with a 5 m buffer of cleared area on each side with topsoil stockpiles located up to 20 m away from the trafficable surface. • Travel between dusk and dawn on the Site Access Road and village access road will be limited to essential travel with driving speed limits set to reduce the potential for road strikes. • The site induction program will provide information on fauna of conservation significance, including their appearance and habitats. • Sheffield will undertake pest animal control in co-operation with regional control programs. • Domestic waste facilities will be fenced and putrescible wastes will be regularly covered. • Borrow pits will be designed and constructed to minimise surface water ponding after rehabilitation. • Firefighting equipment will be located on site and emergency personnel will be trained in fire response. • Lightning protection equipment will be installed as part of project design where necessary. • Vehicles will not be permitted to leave access tracks or cleared areas. • A Hot Work Permit system will be developed and implemented. • All machinery and vehicles undertaking clearing activities will be fitted with firefighting equipment. • Sheffield will work with the pastoralist, Traditional Owners and DFES to undertake prescribed burns and install and maintain firebreaks if required so that potential environmental damage from extreme and out of control wildfires is minimised and infrastructure and the community are protected throughout the life of the project. • The project site induction will include information on the prevention and management of fires. • Lights will be strategically placed and designed to shine towards plant operations and minimise light spill to the environment. • Equipment design will be specified to be within Australian standard noise limits. • Artificial water sources will have egress points installed. • Open holes, trenches, the refuse impoundment, and any water holding facilities will be inspected regularly for fauna. • Domestic waste facilities will be fenced and putrescible wastes will be regularly covered.	It is likely that clearing associated with the project will result in some habitat fragmentation, but the impacts on terrestrial vertebrate fauna (including conservation significant species) and SREs are likely to be incidental due to availability of habitat outside the Mine Site Development Envelope and the progressive nature of the majority of land clearing. The presence of pest species, light, noise, and radiation may affect fauna, however these impacts are not considered likely to cause fauna injury or mortality. Fauna injury or mortality due to vehicle strikes, fire, or entrapment may occur, however are not considered likely to impact native fauna population viability or diversity. These impacts are able to be adequately managed by mitigation and management measures. Sheffield considers that the potential impacts to terrestrial fauna will be able to be adequately managed such that the environmental objective for terrestrial fauna will be met, and that the residual impacts are therefore acceptable.

Factor	EPA Objective	Existing Environment	Potential Impact	Management Measures	Predicted Outcomes
Hydrological Processes	*To maintain the hydrological regimes of groundwater and surface water so that existing and potential uses, including ecosystem maintenance, are protected.*	The water table on the Dampier Peninsula is deep inland and becomes progressively shallower on the coastal plain where discharge occurs at coastal springs in the mud flats around Broome. The Baskerville anticline divides groundwater flows, with water flowing northward north of the anticline and south to southwest in areas south of the anticline. The Mine Site Development Envelope is located on sandy soils with low runoff generation and there are no defined watercourses within the main mine development areas. The nearest watercourses are the Fraser River South, which has a visible channel from approximately 10.5 km downstream of the mineral deposit area. There are no year round surface water bodies within the Mine Development Envelope. The nearest ephemeral pools are approximately 25 km downstream on Fraser River South. (Laws 1991; MBS 2016a).	• Groundwater abstraction and dewatering causing localised lowering of groundwater levels causing vegetation decline in groundwater dependent ecosystems. • Infrastructure causing localised reduction in surface water volumes. • Infrastructure changing local drainage patterns and increasing flood risk. • Surface water management structures causing localised erosion and sedimentation	• Recycling of water within the process water circuit will be implemented to minimise abstraction needs and water waste. • Monitoring bores will be established to assess potential groundwater drawdown and mounding impacts. This will include monitoring bores in the shallow strata of Fraser River South and Soak areas. • All groundwater abstraction, monitoring and reporting activities will be conducted in accordance with relevant permits and licences. • Only the volume of water required for ore processing and safe mining operations will be abstracted. • Flow meters will be fitted to groundwater abstraction bores to enable monitoring of abstraction volumes. • Process water storage facilities will be designed to minimise seepage. • Roads and access tracks will be constructed with appropriate surface water drainage structures to minimise impacts on surface water flows. • Diversion bunds will be constructed around active mine pit areas to prevent surface water runoff from entering active mining areas. • Where necessary, suitable floodways, drains and culverts will be installed to transfer flow past infrastructure and return it to its natural flow path. • Pipelines will be buried when crossing watercourses to prevent impediment of flow. • Appropriately engineered surface water management structures will be constructed to redistribute flow downstream where no suitable natural channels are present.	Drawdown of the groundwater table resulting from mine dewatering and abstraction from a water supply borefield is predicted to be contained largely within the mining lease and it is anticipated that any impact to nearby ecosystems, if this occurs, will be gradual and minimal. Monitoring bores are proposed as a precautionary measure, with trigger levels and mitigation measures implemented to maintain water levels should this area be shown to be impacted by groundwater drawdown. Part of the reinjection borefield could be relocated to maintain water levels in this area if required. The nearest licensed users and nearest registered Aboriginal heritage sites are unlikely to be affected as they are at least 30 km from the project, outside the modelled drawdown. There are no other major developments taking place surrounding the project and there will be no cumulative impacts on hydrological processes. Any impacts to surface water flows from project infrastructure are likely to be minor and localised, and any associated erosion or sedimentation is expected to be highly localised. Sheffield considers that the potential impacts of the project to hydrological processes will be able to be adequately managed such that the environmental objective for hydrological processes will be met, and that the residual impacts are therefore acceptable.

Factor	EPA Objective	Existing Environment	Potential Impact	Management Measures	Predicted Outcomes
Inland Waters Environmental Quality	*To maintain the quality of groundwater and surface water, sediment and biota so that the environmental values, both ecological and social, are protected.*	Groundwater in the Broome Sandstone Aquifer is predominantly of sodium – chloride type, with elevated levels of bicarbonate in some areas. Silica levels are high, with reported values of 18 to 119 mg/L. Nitrate levels are frequently over 40 mg/L, probably as a result of nitrate fixation by native acacias and termite activity. A saltwater interface occurs within the Broome Sandstone aquifer along the coastline. No surface water quality monitoring data is available for the Mine Site Development Envelope or elsewhere on the Dampier Peninsula. Given the lack of industry and other sources of potential contamination, surface runoff is expected to be of good quality suitable for livestock and agricultural use. (Laws 1991)	• Exposure of contaminating materials causing contamination of surface water and groundwater. • Accidental spills causing contamination of surface water and groundwater. • Poor waste management causing contamination of surface water and groundwater. • Release of poor quality water causing contamination of surface water and groundwater.	• Prior to commencement of mining below the water table, additional acid sulfate soils (ASS) sampling and analysis of potentially sulfidic material at depth within the mine deposit area will be undertaken. • If additional sampling indicates potential issues with ASS, a Management Plan will be developed and implemented. • Conduct groundwater monitoring for groundwater levels and quality within the Mine Site Development Envelope. • Water collecting in the mining excavation will be directed into holding sumps and used for dust suppression or ore processing. • Refuelling and fuel delivery inlets will be located on concrete or HDPE-lined pads to contain any drips and spills. The pads will drain to a sump to allow removal of collected material. • A bunded and sealed assembly area for hazardous chemicals (containerised) prior to offsite treatment/disposal will be established. • Transformer stations will be in bunded areas which meet the requirements of Australia Standards AS1940, AS 2067 and AS 3007. • The power station day tank, waste oil tank and lubricants will be located in a bund that complies with Australian Standards AS1940 and AS1692. • All hydrocarbon and chemical storages will be designed and constructed in accordance with Australian Standards AS1940 and AS1692. • Equipment and vehicles including surface mobile equipment shall be subject to a regular maintenance program to reduce the likelihood of spills and leakages occurring. • Heavy, light vehicle and maintenance workshop facilities will be located on concrete pads and hydrocarbon spillages and leakages captured and appropriately managed through the use of hydrocarbon absorbent materials. • Hydrocarbon wastes will be segregated from other wastes and collected for offsite disposal by a licensed contractor. • The transport, storage or use of any designated Dangerous Good or substance will be conducted in accordance with Dangerous Goods permits as required and in accordance with Dangerous Goods Safety Act 2004, Dangerous Goods Safety (Road and Rail Transport of Non-Explosives) Regulations 2007 and Dangerous Goods Safety (Explosives) Regulations 2007. • Monitoring and assessment program for surface and groundwater will be implemented as required and will include environmental quality analysis for parameters agreed with by regulatory authorities. • Spill kits will be located at strategic locations throughout the project area and employees trained in their use. • Spills will be contained, remediated, investigated and reported to the relevant authorities as required. • WWTP will be constructed, operated and maintained in accordance with the Department of Environment Regulation (DER) Works Approval, Environmental Licence and local government and Department of Health regulations and permitting requirements as issued by the Shire of Broome. • Effluent produced by the WWTPs will either be irrigated to the environment or reused for dust suppression. • The WWTP will be fitted with alarms and be able to be shut down the plant should a failure occur. • WWTPs will be regularly inspected and discharge suspended if it is discovered they are operating below the required standard. • The WWTP will have contingency storage capacity for up to two days of normal flow if discharge is suspended while any problems are addressed. • Effluent discharge from the WWTP will be managed to allow effluent to infiltrate or evaporate and prevent surface ponding or runoff from the irrigation area. • Domestic wastes will be disposed of into a purpose built onsite landfill. • The landfill will have a boundary fence to prevent fauna access (specifically feral animals) and to create a wind barrier. • An entrance/exit gate within the boundary fence will be kept closed other than when waste is being deposited. • Recyclable wastes will be collected in a laydown area and transported offsite for recycling. • A lined Process Water Dam will be constructed in order to store water from mine dewatering operations and process water from the borefield.	The potential to generate environmentally harmful acidic runoff through excavation or dewatering ASS is not considered a risk for the majority of the project materials. However, samples of material found at depth within the mine deposit area were considered potentially acid forming (PAF) and may be reached in the final years of the proposed 40+ year mine life. These materials will be further defined and managed through developed management plans at a suitable point in the life of the mine. Any contaminated flow leaving the Mine Site Development Envelope will be rapidly diluted by inflow from other catchments, effectively ameliorating impacts on some water quality parameters. Additionally, there are no defined water course channels within the mine deposit and ore processing plant areas, where environmentally hazardous materials and processes will be predominantly stored and used. Groundwater within the underlying strata is deep (≥ 20m), and localised surface contamination is unlikely to seep to groundwater in any significant concentrations. There are no other major developments taking place surrounding the project, hence there will be no cumulative impacts on inland water quality. Sheffield considers that the potential impacts to inland water quality will be able to be adequately managed such that the environmental objective for inland environmental quality will be met, and that the residual impacts are therefore acceptable.

Factor	EPA Objective	Existing Environment	Potential Impact	Management Measures	Predicted Outcomes
				• All HDPE-lined ponds shall be designed to have a controlled release point to prevent over topping. • Sufficient freeboard will be maintained in water storages to allow capture of rainfall from a one in one hundred year 72 hour ARI event. • Water in the Process Water Dam will be reused within the WCP. • Detailed TSF design compliant with the Code of Practice for Tailings Storage Facilities in Western Australia (DMP 2013) and ANCOLD Guidelines on Tailings Dam Planning, Design, Construction, Operation and Closure (ANCOLD 2012). • A biodegradable flocculent will be used to assist in settling of suspended clay/silt material from process water.	
Heritage	*To ensure that historical and cultural associations, and natural heritage, are not adversely affected.*	No registered Aboriginal sites or other heritage places of significance are located within the Mine Site Development Envelope. Aboriginal heritage surveys to support exploration activities have been undertaken in consultation with Traditional Owners annually since 2012. The outcomes of the surveys were: • The project area has been extensively and comprehensively surveyed, and all areas considered sensitive to Aboriginal cultural values in the Mine Site Development Envelope and surrounds have been covered. • Aboriginal sites and areas of Aboriginal cultural value have been identified and mapped. • Avoidance buffer zones have been determined by Native Title claimants (AHA 2016).	• Ground disturbance causing impacts to known Aboriginal heritage sites and landscape cultural values. • Ground disturbance causing impacts to unknown Aboriginal heritage sites. • Project activities causing impacts to groundwater and groundwater dependent ecosystems.	• Development and implementation of Aboriginal Heritage Management Operations Framework and Cultural Heritage Management Plan. • Maintain buffer zones around important Aboriginal sites and areas with Aboriginal heritage values in the Mine Site footprint and surrounds. • Maintain consultation with Traditional Owners. • Disturbance of Aboriginal heritage sites to be consistent with agreements with Native Title claimants and Aboriginal Heritage Act 1972. • Develop and implement procedures for discovery of new Aboriginal heritage cultural materials (Aboriginal Heritage Management Operations Framework). • Conduct additional surveys in consultation with Traditional Owners where required. • Sheffield is seeking a Mining Agreement with the Native Title claimant.	Database searches found no Aboriginal heritage or other heritage places on the Register of Aboriginal sites (Section 4.2.12.1) within the Development Envelope. The Mine Site Development Envelope has been surveyed by Traditional Owners, and all (unregistered) culturally important areas have been identified and mapped. Buffer zones have been defined to protect known heritage sites or culturally important areas within the Mine Site Development Envelope. There is a possibility that unknown archaeological heritage sites or ancestral remains within the Mine Site Development Envelope may be found, however, Sheffield are effectively managing this through implementation of the Heritage Management Framework (Appendix 26) and a Heritage Management Plan to be developed with Traditional Owners. It is anticipated that this will eliminate the prospect of any inadvertent damage to these findings. Any impact to known Aboriginal heritage will only occur in accordance with agreements reached with the Native Title claimants and the *Aboriginal Heritage Act 1972.* Sheffield considers that the potential impacts to heritage will be adequately managed such that the objective for heritage will be met, and that the residual impacts are therefore acceptable

Factor	EPA Objective	Existing Environment	Potential Impact	Management Measures	Predicted Outcomes
Key Environmental Factors – Derby Port Development Envelope					
Marine Environmental Quality	*To maintain the quality of water, sediment and biota so that the environmental values, both ecological and social, are protected.*	Estuarine tidal water sampled at the public boat ramp located to the immediate west of the proposed storage facility indicate no results above the ANZECC and ARMCANZ Ecological Investigation Levels trigger values. Concentrations of dissolved metals and metalloids were mostly below laboratory limits of reporting (including for lead, zinc, copper and nickel). As expected for the silt laden waters of this estuary area, the turbidity (62 nephelometric turbidity units) and suspended solids (89 mg/L) were very high. Other general parameters of salt content and salt composition are consistent with typical seawater. Dissolved uranium was observed at a concentration of 0.0035 mg/L, which is consistent with the value reported by Miyake et al. of 0.0033 mg/L for seawaters of the western north Pacific. The upper reaches of King Sound are naturally high in turbidity, primarily as a result of Fitzroy River discharge, with suspended solids concentrations reaching 3 kg/m^3. (ANZECC and ARMCANZ 2000; MBS 2016b)	• Installation of mooring points increasing turbidity • Product dust or spillage causing marine pollution • Hydrocarbon spill causing marine water and sediment pollution • Radiation impacting the marine environment	• Sheffield will either upgrade or replace existing moorings installed at transhipment vessel and ship loading points within Derby Port limits. • The Product Storage Facility will include a drive through enclosed unloading area to ensure product is contained within facility during unloading activities. • Transfer of product to the barge will be via a covered conveyor to minimise escape of dust or spillage. • Refuelling of marine vessels will be consistent with Port of Derby requirements. • Used oil or oil-soaked absorbents will be securely stored and disposed of at a licensed facility to reduce the chance of oil, fuel or any oily wastes being discharged into the marine environment. • Refuelling equipment will include an emergency shutdown valve and will be monitored at all times. • Spills of oil, fuel or other hydrocarbons to water will be immediately reported to DoT for advice. • A spill kit located at Derby Port will be maintained in working order. • An appropriately sized and stocked marine spill kit will be located on each Sheffield owned or operated tug boat to address small scale spillages. • Management of hydrocarbons and potential spills is addressed in the Port Environmental Management Plan. • Background radiation levels in soil, sediments and airborne dust will be measured prior to construction commencing. • Spillages of product on land will be cleaned up as required. Spilt product will either be returned to the Product Storage Facility or returned to the Mine Site for reprocessing or disposal.	King Sound is a highly dynamic environment with very high turbidity which occurs naturally as a result of the Fitzroy River and other oceanographic processes. Any additional turbidity generated from the installation of new moorings will be short term, localised and the large tidal exchange will ensure water quality remains close to baseline levels. Some minor generation of dust or spillage of product is likely throughout the life of the project; however, it is considered that it will not result in any discernible changes to the quality of water, sediment or biota in King Sound or adjacent waters. Mineral sands products occur naturally in King Sound and are environmentally benign. Spillage of hydrocarbons is possible during refuelling operations; however volumes will be minimal due to the mitigation measures proposed. The mineral sands products have very low to insignificant levels of natural radiation. Spillage of products into the marine environment is not expected to result in significant impacts to the marine environment and will not result in any discernible changes to the quality of water, sediment or biota in King Sound or adjacent waters. Sheffield considers that the potential impacts to marine environmental quality will be able to be adequately managed such that the environmental objective for marine environmental quality will be met, and that the residual impacts are therefore acceptable.

Factor	EPA Objective	Existing Environment	Potential Impact	Management Measures	Predicted Outcomes
Amenity	*To ensure that impacts to amenity are reduced as low as reasonably practicable.*	Historically, the Great Northern Highway, Derby Highway, Loch Street and Jetty Road have been used to transport lead and zinc metal concentrates from the Lennard Shelf Operations, located east of Fitzroy Crossing, to Derby Port. While the Lennard Shelf Lead and Zinc Operations were operational (1997 - 2008), up to 500,000 tonnes per annum of lead and zinc concentrates were transported along the transport route from east of Fitzroy Crossing to Derby Port. With respect to visual amenity at the Derby Port, there are several buildings of single storey currently existing. The site is zoned for industry and includes the wharf, conveyor and existing buildings on the wharf. (MBS 2009)	• Dust emissions causing a decrease in amenity for sensitive receptors • Noise emissions causing a decrease in amenity for sensitive receptors	• Bulk products will be transported to the Derby Port Development Envelope in covered containers. • Bulk product will be stored in a purpose built Product Storage Facility. This will include a drive through enclosed unloading area to ensure product is contained. • Transfer of product to barges will be via a covered conveyor. • Spillages of product on land will be cleaned up as required. Spilt product will either be returned to the Product Storage Facility or returned to the Mine Site for reprocessing or disposal. • Road trains will be maintained in good mechanical condition to minimise noise associated with their operation. • The use of engine brakes within the built-up area of Derby will only be permitted for emergency breaking. • Road train speed limits through the town of Derby will be determined in consultation with the Shire of Derby/West Kimberley, Main Roads WA and other stakeholders. • Sheffield will develop and implement a community feedback and complaints mechanism.	Derby Port is currently a functioning industrial site within a zoned industrial area. Ambient concentrations for dust at the Port boundary and along the transport route will be within accepted limits and will not impact on sensitive receptors in Derby. Modelled noise levels as a result of the project are below DER 1 hr LAeq noise limits as defined in the *Environmental Protection (Noise) Regulations 1997* for receptors. Noise impacts on sensitive receptors in the town of Derby are unlikely to cause loss of amenity for Derby residents and Port users. Sheffield considers that the potential impacts to amenity will be able to be adequately managed such that the environmental objective for amenity will be met, and that the residual impacts are therefore acceptable.
Other Environmental Factors – Mine Site Development Envelope					
Landforms	*To maintain the variety, integrity, ecological functions and environmental values of landforms.*	From an initial review of regional contours surrounding the Mine Site Development Envelope (up to 30 km away), the most distinctive landforms in relation to the Mine Site Development Envelope are a north-west to south-east trending band of low hills parallel to the Mine Site Development Envelope associated with the Reeves Land System. The distinctive landform features within the band are Reeves Hill, Dampier Hill, Mt Jowlaenga and several unnamed smaller hills to the east and north of the Mine Site Development Envelope. None of these landforms will be impacted by the project.	• Post-mining landforms are inconsistent with the surroundings. • Post-mining landforms are unstable.	Management measures for constructed landforms are detailed in the preliminary MCP ().	Two constructed landforms will remain at closure of the project - the mineral deposit area and the initial TSF. The mineral deposit area will be progressively backfilled and rehabilitated and will not be significantly distinguishable from the surrounding area. The initial TSF surface at the end of mine life will potentially be elevated in excess of 10 m above the surrounding landscape and hence will be more pronounced. This will be shaped and rehabilitated to match surrounding landforms as outlined in the preliminary MCP. Due to the lack of impact on existing landforms from project activities, Sheffield considers that the environmental objective for landforms will be met.

Factor	EPA Objective	Existing Environment	Potential Impact	Management Measures	Predicted Outcomes
Subterranean Fauna	*To maintain representation, diversity, viability and ecological function at the species, population and assemblage level.*	Survey results identified a low diversity and abundance of subterranean fauna with no stygofauna being recorded during the survey. Similarly to stygofauna, there appears to be a low diversity and abundance of troglofauna present, this is potentially due to the habitat being dominated by Pindan sand plains which have little or no cavernous or vuggy habitat space. Only a single specimen (Staphylinidae sp. Indet) was recorded within the Mine Site Development Envelope. (Ecologia 2014a)	• No impacts expected	No management measures are required for subterranean fauna.	Due to the lack of subterranean fauna being recorded within the Mine Site Development Envelope and immediate surroundings, the project will not result in loss to the representation, diversity, viability or ecological function of subterranean fauna species, population and assemblages. Sheffield considers that the environmental objective for subterranean fauna will be met.
Terrestrial Environmental Quality	*To maintain the quality of land and soils so that the environment values, both ecological and social, are protected.*	Soils in the Mine Site Development Envelope are dominated by red sands (Pindan) of aeolian origin, which are widespread throughout the Dampier Peninsula. Soil profiles are typically deep (greater than 1 m), although relatively shallow profiles were recorded at several locations where Cretaceous sandstone sedimentary rocks or silcrete hardpan were present within 1 m of the natural soil surface. Minor soil types included deep yellow sand and shallow bleached sand over clay or loam, usually associated with drainage lines or depressions. The Mine Site Development Envelope is characterised in the Australian Soil Resources Information System Acid Sulfate Soil mapping as having 'Extremely Low' probability (low confidence) of occurrence within 2 m of the natural soil surface.	• Erosion and sedimentation causing loss of topsoil. • Erosion and sedimentation causing loss of soil material from disturbed areas. • Disposal of mine and processing wastes causing contamination of the environment • Accidental spills and leaks causing contamination of the environment • Discharge of inadequately treated sewage effluent causing contamination of the environment. • Poorly designed and operated landfill causing contamination of the environment.	• Dust will be managed by watering unsealed roads with a water cart or with fixed sprays as required. • Vehicle traffic will be confined to defined roads and tracks. • During high winds, topsoil and overburden stripping and spreading activities will be restricted if dust cannot be adequately controlled. • Vehicles will be required to travel at safe operating speeds on unsealed roads and will be restricted from accessing rehabilitated surfaces except for management purposes. • Spilt ore and materials outside of the ore processing areas will be regularly cleaned up. • Bulk products will be transported in covered containers. • Rehabilitated areas will be monitored to ensure radiation levels are within environmental screening criteria (10 µGy/h) or established pre-mining background levels. No further specific management measures for terrestrial environmental quality are required as management measures detailed in Section 8.1.2 for flora and vegetation, Section 8.4.3 inland water quality and Section 12 rehabilitation and decommissioning adequately mitigate impacts to terrestrial environmental quality.	Mine wastes are expected to be benign apart from sulfidic material measured at extreme depth, with monitoring and management measures to be developed and implemented before this material is disturbed. Sheffield considers that the potential impacts on terrestrial environmental quality will be able to be adequately managed such that the objective will be met, and that the residual impacts are therefore acceptable.

Factor	EPA Objective	Existing Environment	Potential Impact	Management Measures	Predicted Outcomes
Air Quality and Atmospheric Gases	*To maintain air quality for the protection of the environment and human health and amenity, and to minimise the emission of greenhouse and other atmospheric gases through the application of best practice.*	There are no significant emissions sources in the vicinity of the Mine Site and due to the remote location, it is presumed that air quality will typically be very good. The main contributors to dust levels are ambient wind-borne dust (dust storms, cattle and vehicle movements) and smoke from dry season bush fires. Background and cumulative emissions from other industrial activities are expected to be negligible and naturally occurring background particulate concentrations are expected to be minor. During project design, in order to be conservative, the average ambient dust concentrations found in northwest Western Australia have been used to ensure the worst-case scenario is considered (40 µg/m3 for TSP, 20 µg/m3 for PM10 and 7 µg/m3 for PM2.5). These concentrations are based on a number of studies of ambient monitoring in the Kimberley and Pilbara areas, which both experience a higher level of activity than the Mine Site Development Envelope and as such are seen to be a conservative choice in lieu of local data. (Atmospheric Solutions 2016a)	• Dust emissions affecting air quality from: – Mining activities – Fixed stacks associated with the mineral processing plant. – Handling and transport of mined material, process material and final product. – Stored mine wastes • Combustion emissions affecting air quality: – Oxides of nitrogen. – Carbon monoxide. – Sulfur dioxide. • Greenhouse gas emissions	• During high winds, topsoil stripping and spreading activities will be restricted if dust cannot be adequately controlled. • Vehicles and mining equipment will keep to designated roads. • Vehicles will be required to travel at safe operating speeds on unsealed roads and will be restricted from accessing rehabilitated surfaces except for management purposes. • Clearing will be undertaken progressively and kept to the minimum requirement. • Progressive rehabilitation will be undertaken on disturbed areas as they become available. • Dust suppression will be carried out during construction, operation and closure. • Sheffield will maintain equipment in accordance with manufacturers' specifications to minimise particulate and gaseous emissions. • Vehicles and plant will undergo regular preventative maintenance and, as needed, corrective maintenance. • Euro V standard vehicles and equipment (post 2009) or appropriate quality diesel fuel will be used to minimise NOx and particulate emissions. • Energy efficiency has been considered in the selection and design of equipment and plant. • Sheffield will specify preference for use of low emission producing equipment in equipment supply contracts.	The results of modelling indicate that all pollutants, both dust (TSP, PM10, PM2.5 and dust deposition) and combustion products (NOX, CO, SO2), will be well within the assessment levels at appropriate distances from the activity and nearby receptors such as the accommodation village. No residential receptors outside the Mine Site Development Envelope will be impacted by pollutants. Potential air quality impacts from the project may occur as a result of dust generated by the construction, mining, processing, handling and transport of the mined material, as well as low levels of gaseous combustion emissions from onsite power generation and process heat requirements. Dust generation is the primary contributor to potential air quality impacts for the project, however use of dust suppression along the Site Access Road around the Mine Site will adequately control dust emissions. The project is not expected to result in any adverse air quality impacts in the region (Appendix 12). Sheffield considers that the potential impacts to air quality will be able to be adequately managed such that the environmental objective for air quality will be met, and that the residual impacts are therefore acceptable.

Factor	EPA Objective	Existing Environment	Potential Impact	Management Measures	Predicted Outcomes
Human Health	*To ensure that human health is not adversely affected.*	N/A	• Radiation exposure affecting the health of mine workers • Radiation exposure affecting the health of process plant workers • Radiation exposure affecting the health of members of the public	• The mine will be registered under the RSA with the Radiological Council and DMP and Sheffield will appoint a Radiation Safety Officer (RSO) to implement a Radiation Management Plan (RMP) and the Radiation Waste Management Plan (RWMP) on behalf of Sheffield. • Provision and maintenance of equipment and facilities for controlling radiation sources, including housekeeping, dust suppression and surface contamination control to maintain a duty of care to employees and the public. • A radiation monitoring program will be developed and implemented in consultation with Radiological Council and DMP. This will include monitoring of personal exposure for mine and process plant workers, hand held gamma monitoring and monitoring of airborne dust scintillation counting (Bq/m^3) and radon. • Processing and mining wastes will be blended prior to final disposal as backfill within the mining excavation in accordance with a prepared RWMP. • Rehabilitated areas will be monitored to ensure radiation levels are within environmental screening criteria (10 µGy/h) or established pre-mining background levels.	The predicted dose to mine workers and process plant workers was estimated to be 2.15 mSv/year and 3 mSv/year respectively, which is well below the dose rate limit for radiation workers of 20 mSv/year. The predicted dose to a member of the public was considered to be negligible and below assessable levels. All activities at the Mine Site associated with the project will be undertaken in accordance with the Radiation Safety Act. Sheffield will engage a Radiation Safety Officer (RSO) upon the implementation of a Radiation Management Plan (RMP) and a Radiation Waste Management Plan (RWMP), to implement periodic personal and environmental monitoring of radiation levels for formal reporting to the Radiological Council and the DMP. Implementation of these arrangements will ensure that any potential radiation doses to workers, the public and the environment will be monitored, controlled and minimised to ensure that all legal requirements are met and that radiation doses are below regulatory limits. Sheffield considers that the potential impacts of radiation to human health will be able to be adequately managed such that the objective will be met, and that the residual impacts are therefore acceptable.
Other Environmental Factors – Derby Port Development Envelope					
Benthic Communities and Habitat	*To maintain the structure, function, diversity, distribution and viability of benthic communities and habitats at local and regional scales.*	Mangrove communities (mangals) in the Kimberley region display a very high degree of intactness. Mangrove forests are the most important benthic primary producers in the wider Derby Port area. At Derby Port, vegetation surrounding the proposed storage facility is dominated by mangals that lie in a 500 m wide band between the open water of King Sound and extensive saline mudflats. Inshore areas of King Sound are not likely to support seagrasses, as it is an area of extremely high turbidity levels and large tidal movements. (EPA 2009; Semeniuk 1980)	• Installation of mooring points disturbing benthic communities and habitats • Anchoring disturbing benthic communities and habitats	• Sheffield will either upgrade or replace existing moorings installed at transhipment vessel and ship loading points within Derby Port limits. • Dropping anchor by ocean-going vessels outside King Sound to collect the pilot will be confined to the pilot boarding area approved by the relevant Port authority in order to minimise damage to benthic communities and habitats.	Installation of new moorings may cause direct disturbance within the mooring zones, however this is unlikely to impact the overall function of any benthic communities or habitats within King Sound. Dropping of anchor by the ocean-going vessel at the pilot boarding point may cause localised damage to any benthic communities and habitats, but due to the low benthic light levels which are characteristic of deeper waters, it is considered that there will not be any change to the structure, function, diversity, distribution and viability of benthic communities and habitats. Sheffield considers that the potential impacts of mooring point installation and anchoring on benthic communities and habitats will be able to be adequately managed such that the objective will be met, and that the residual impacts are therefore acceptable.

Factor	EPA Objective	Existing Environment	Potential Impact	Management Measures	Predicted Outcomes
Marine Fauna	*To maintain the diversity, geographic distribution and viability of fauna at the species and population levels.*	For the marine and migratory species, a total of 40 birds, 32 fish (including sharks and rays), 16 mammals and 22 reptile species were identified during the database searches. Most of the species are common and well represented in the region. There are 36 species of migratory birds protected under international agreements that may overfly the Derby Port area. The Humpback Whale is known to occur in significant numbers in the Kimberley region. Three species of dolphin of conservation significance that may occur: Australian Humpback Dolphin, Snubfin Dolphin and Indo-Pacific Bottlenose Dolphin. While it is possible for Whale Sharks to occur in King Sound, the species is considered an oceanic species preferring clear water. Six of the seven species of sea turtle worldwide have the potential to occur: the Flatback Turtle, Green Turtle, Hawksbill Turtle, Leatherback Turtle, Loggerhead Turtle, and the Olive Ridley Turtle. Sawfish are known to occur in the King Sound area: Dwarf Sawfish, Green Sawfish, and Largetooth Sawfish. The Northern River Shark is known from King Sound. (DoE 2016; DPaW 2016a)	• Noise from construction and operational activities at Derby Port impacting birds or terrestrial fauna • Light from construction and operational activities at Derby Port impacting birds or terrestrial fauna • Changes in hydrological regimes at the Mine Site Development Envelope impacting Sawfish species or Northern River Shark. • Additional shipping and transhipment impacting marine fauna – these could be direct or indirect through: – Vessel strike. – Noise. – Light. – Hydrocarbon spill. • Solid waste/marine debris.	• Lighting design will consider minimisation of attraction of wildlife. • Operators of the ocean-going vessel will be made aware of potential lighting impacts to marine fauna and the advice of Environmental Assessment Guideline No. 5, Protecting Marine Turtles from Light Impacts (EPA 2010). • Culverts will be constructed at the channel of the Fraser River South where it crosses the Site Access Road to facilitate wet season surface water flows and allow the passage of juvenile Sawfish. • If crew of Sheffield operated vessels sight cetaceans or sea turtles, these will be reported to other vessels to ensure they are informed and can take precautions in the area. • Captains of ocean-going vessels will be informed to take extra care during the Humpback Whale migration season (July to November), adjust vessel speeds and have crew on watch as needed. • Sheffield operated vessels will reduce speed below 8 knots if whale sightings are within vessel movement areas. • Any wildlife strikes by Sheffield operated vessels will be reported through an incident reporting system and adaptive management practices implemented if necessary. • All Sheffield marine vessels will be maintained to high standards as required by DoT. Refuelling of marine vessels will be consistent with Port of Derby criteria. • Refuelling equipment will include emergency shutdown valves and be monitored at all times. • Used oil or oil-soaked absorbents will be securely stored and disposed of at a licensed facility. • Spills of oil, fuel or other hydrocarbons to water will be immediately reported to DoT. • A spill kit located at Derby Port will be maintained in working order. • An appropriately sized and stocked marine spill kit will be located on each Sheffield owned or operated tug boat to address small scale spillages. • Employees and contractors operating Sheffield transhipment vessel and tug boat teams will be made aware of the importance of preventing the escape of solid waste. • Solid waste will be disposed of in appropriately covered receptacles at Derby Port and transferred to a licensed disposal facility. • The Captain of the ocean-going vessel will be provided with information on the legal obligations of preventing the escape of solid waste.	Derby Port is an existing facility and the transhipment and shipping routes have been used historically. The increase in shipping movements is minimal, representing an additional 2.6% per year (based on the year 2014/15). This minimal increase in vessel movements will result in negligible increases in noise and light emissions or solid waste impacts. Therefore, it is not anticipated that these minimal increases will result in any loss of conservation significant fauna habitat or individuals of a conservation significant species, or change to breeding patterns or behaviour of marine fauna. Whilst hydrocarbon spills and vessel strikes could result in the death of an individual animal of conservation significance, it is unlikely that such an event would occur and it is not anticipated that this would affect the ability of the population of that species to survive in King Sound or the vicinity. Sheffield considers that the potential impacts of the project on marine fauna will be able to be adequately managed such that the objective will be met, and that the residual impacts are therefore acceptable.

Factor	EPA Objective	Existing Environment	Potential Impact	Management Measures	Predicted Outcomes
Terrestrial Environmental Quality	*To maintain the quality of land and soils so that the environment values, both ecological and social, are protected.*	The soils of the Derby region belong to the Dampier Sandplain zone, comprising sandplains, dunes and coastal mudflats overlying the sedimentary rocks of the Canning Basin. Locally, the dunes and sandplains belong to the Yeeda system. The soils are referred to as 'Pindan'. They are usually red-brown sands to sandy earths and are believed to be of aeolian origin. Soils from the dunes tend to have a higher sand content than those of the associated swales. (MBS 2009)	• Dust generation or spillage of product affecting the terrestrial environment • Radiation exposure affecting the terrestrial environment • Disturbance of contaminated or acid sulfate soils affecting the terrestrial environment	• Bulk products will be transported in covered containers. • Bulk product will be stored in a purpose built Product Storage Facility. This will include a drive through enclosed unloading area to ensure product is contained within warehouse during unloading activities. • Product storage and loading onto the conveyor will be conducted within the shed. • Transfer of product to barges will be via covered conveyor. • The RMP will define the requirements for periodic monitoring for both personal and environmental monitoring of radiation levels. This will include establishment prior to operations of background soil, sediment and airborne dust samples. • Products spills along the transport route or Derby Port will be subject to clean up such that residual levels of radiation are returned to established background levels. Material collected from any such spills or accidental release will be returned to the Mine Site for re-processing or disposal. • Background radiation levels in soil, sediments and airborne dust will be measured prior to construction commencing.	The potential for impacts to terrestrial environmental quality as a result of transport, storage and export of product within the Derby Port Development Envelope is minimal. All transport of product is via covered road trains on sealed roads. These unload in an enclosed facility and product is loaded onto a conveyor within a bunded area. The product itself is granular, has a high specific gravity, and is not prone to producing dust, although some minor generation of dust may occur throughout the life of the project. The product is naturally occurring with a low level of radiation and is environmentally benign. Soils at the site are not potentially ASS and the project will not result in any significant disturbance to soils or marine sediment within the Derby Port Development Envelope. The project will not result in loss of soil resources or associated environmental values. Sheffield considers that the potential impacts of dust, radiation, and contaminated soils on terrestrial environmental quality will be able to be adequately managed such that the environmental objective will be met, and that the residual impacts are therefore acceptable.

Factor	EPA Objective	Existing Environment	Potential Impact	Management Measures	Predicted Outcomes
Human Health	*To ensure that human health is not adversely affected.*	N/A	• Radiation exposure affecting the health of transport drivers • Radiation exposure affecting the health of workers • Radiation exposure affecting the health of members of the public • Dust emissions affecting the health or workers or members of the public • Diesel particulate and gaseous vehicle emissions exposure affecting the health of members of the public	• Provision and maintenance of equipment and facilities for controlling radiation sources, including housekeeping, dust suppression and surface contamination control to maintain a duty of care to employees and the public. • The facility will be registered under the RSA with the Radiological Council and DMP and Sheffield will appoint a Radiation Safety Officer (RSO) to implement a Radiation Management Plan (RMP) on behalf of Sheffield. • A radiation monitoring program will be implemented at the Port in consultation with the Radiological Council and DMP which will define the requirements of monitoring for both personal (and environmental radiation levels. This may include background, operational and post-closure radiation monitoring for personal exposure of Port workers as well as soil, sediment and air samples. • The product transport activities from the Mine Site to Derby Port and Port of Broome will be registered with the Radiological Council and Sheffield will appoint a Radiation Safety Officer (RSO) to implement a Radiation Transport Management Plan (RTMP). • Personal dose monitoring for transport workers (in particular drivers) will be undertaken in accordance with a RTMP by the Radiological Council. • Radiation monitoring of transport trucks leaving the Mine Site and Port facility for external radiation levels using hand held gamma radiation and alpha radiation wipe tests will be conducted in accordance with the RTMP. • Products spills along the transport route or Derby Port will be cleaned up such that residual levels of radiation are returned to established background levels. Material collected from any such spills or accidental release will be returned to the Mine Site for re-processing or disposal. • Bulk Product will be transported in sealed containers. • Bulk product will be stored in a purpose built Product Storage Facility with enclosed drive through unloading area to minimise dust emissions and then loaded onto transhipment vessels using a closed conveyor and/or sealed bags. • Dust monitoring will be conducted in accordance with DMP CONTAM and DER requirements. • Road trains used for the project will employ modern Euro V (post 2009) diesel engines which are maintained according to a regular maintenance schedule.	Radiation can be effectively managed under the Mines Safety and Inspection Act 1995 and Radiation Safety Act 1975 jointly by DMP and Radiological Council of WA. The predicted dose to Derby Port workers was conservatively estimated to be 1.62 mSv/year which is well below the dose rate limit for radiation workers of 20 mSv/year. The predicted dose to transport works was conservatively estimated to be less than 0.5 mSv/year which is below the public limit of 1 mSv/year. The predicted dose to a member of the public was conservatively estimated to be 0.008 mSv/year which is well below the public limit of 1 mSv/year. All activities for transport and handling of product at the Derby Port Facility associated with the project will be undertaken in accordance with the Radiation Safety Act 1975 and Radiation Safety (Transport of Radioactive Substances) Regulations 2012. The facility will be registered under the RSA and the proponent will engage a Radiation Safety Officer on the implementation of a RMP and a RTMP, to implement periodic personal and environmental monitoring of radiation levels for formal reporting to the Radiological Council and DMP. Implementation of these arrangements will ensure that any potential radiation doses to workers, the public and the environment will be monitored, controlled and minimised to ensure that all legal requirements are met and that radiation doses are below regulatory limits. Sheffield considers that the potential impacts of radiation, DPM, and gaseous vehicle emissions to human health will be able to be adequately managed such that the objective will be met, and that the residual impacts are therefore acceptable.

Factor	EPA Objective	Existing Environment	Potential Impact	Management Measures	Predicted Outcomes
Hydrological Processes	*to maintain the hydrological regimes of groundwater and surface water so that existing and potential uses, including ecosystem maintenance, are protected*	Derby Port and the proposed Product Storage Facility are situated on a raised section of reclaimed land. King Sound is located to the immediate northwest and its associated saline mudflats are situated to the immediate east. Stormwater runoff from the reclaimed section of land drains directly to either King Sound or the mudflats. Tidal movements in King Sound are extreme, with a highest recorded tide of 11.8 m. Inundation of the mudflats is rare, but can occur following a high rainfall event or during a spring high tide. The reclaimed land where the proposed Product Storage Facility will be constructed has been raised above the highest recorded tide level.	• The proposed Product Storage Facility will not impact exiting hydrological processes within the Port Development Envelope.	• No management measures are required.	

Factor	EPA Objective	Existing Environment	Potential Impact	Management Measures	Predicted Outcomes
Integrating Factor – Rehabilitation and Decommissioning					
Rehabilitation and Decommissioning	*To ensure that premises are decommissioned and rehabilitated in an ecologically sustainable manner.*	N/A	• Closure obligations prove impractical, and cannot be met. • Premature closure of the mine, potentially leading to exposed tailings material in the TSF and mine pits that remains unrehabilitated. • Injury caused to a member of the public, from accessing unsafe or unstable decommissioned infrastructure, landforms, or voids. • Stormwater ponding or runoff on any remaining mine waste landforms such as the TSF or mineral deposit area, leading to instability and/or erosion and sediment transport. • Insufficient mine waste material to backfill final mine void resulting in the potential formation of a pit lake with increasing salinity trends. • Underestimation of material swell factor resulting in excessive consolidation of backfilled material within mine pits and formation of local depressions and seasonal surface water ponding. • Failure to stockpile sufficient topsoil and growth medium to support revegetation objectives. • A legacy of contaminated sites, accumulated from spills or leaks over the life of mine.	The preliminary MCP has been developed in order to address potential impacts related to rehabilitation and closure (Appendix 4). The preliminary MCP details the following: • Closure obligations and commitments. • Stakeholder identification and engagement. • Post mining land use and closure objectives. • Development of completion criteria. • Closure data. • Identification and management of closure risks. • Closure implementation (including the development of closure domains). • Closure monitoring and maintenance. • Financial provision for closure.	Through the development of the preliminary and detailed MCP, Sheffield considers that potential residual impacts during decommissioning and closure on the environment will be able to be adequately managed such that the environmental objective for rehabilitation and closure will be met, and that the residual impacts are therefore acceptable.

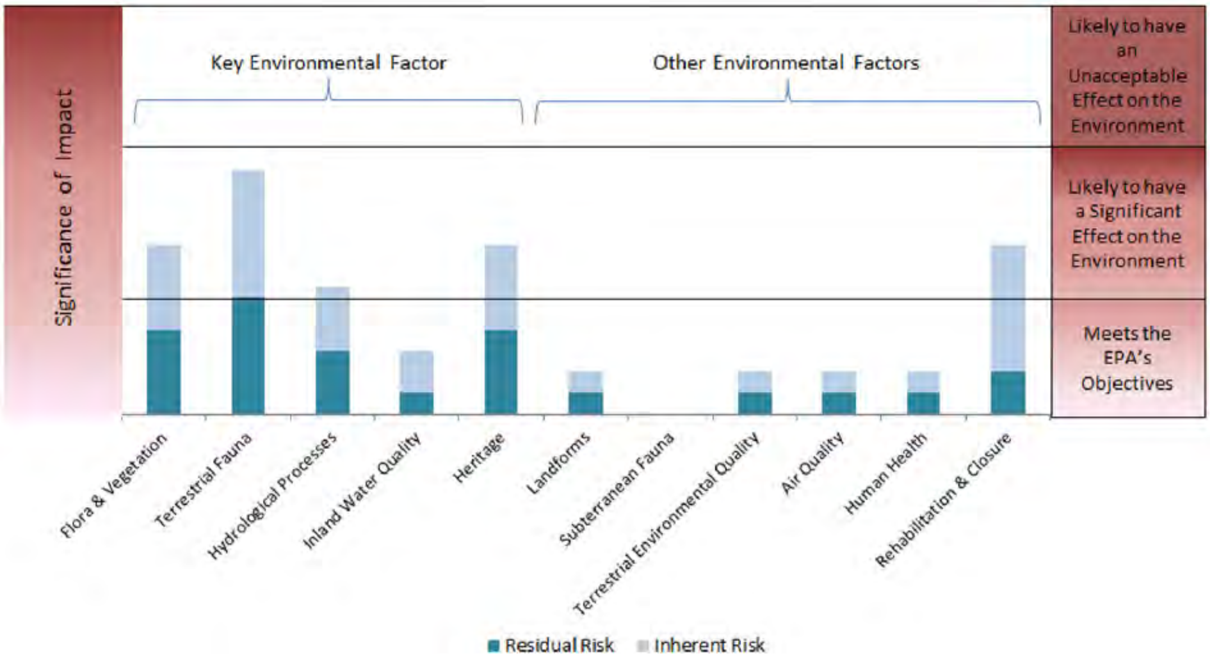
Factor	EPA Objective	Existing Environment	Potential Impact	Management Measures	Predicted Outcomes
Matters of National Environmental Significance					
The Greater Bilby	N/A	The Greater Bilby (or evidence of the species) was identified during the surveys undertaken for the Mine Site Development Envelope. (Ecologia 2014a, 2016)	• Fragmentation of habitat resulting in displacement. • Clearing activities causing injury or death. • Vehicle strike causing injury or death. • Increased predation causing injury or death. • Altered fire regime causing injury or death or loss of habitat. • Light and noise pollution disrupting nocturnal activities. • Entrapment leading to injury or death	• Clearing activities will be managed to ensure clearing is strictly limited to that necessary for operations. • Land clearing will be undertaking progressively with the amount of active disturbance minimised. • Disturbed areas will be rehabilitated as they become available. • Topsoil and vegetation will be respread over rehabilitated areas to act as a seed source and mulch to protect the soil from erosion and provide habitat for fauna. • Pre-clearance surveys will be undertaken no more than one month ahead of planned land clearing. As Bilbies are highly mobile, utilisation of burrows can vary nightly. To ensure pre-clearance surveys are accurate and information is current, the following protocols will be implemented: – The time between pre-clearance surveys and clearing will be minimised a far as practicable. – Locations of burrows previously identified in the clearing area (both active and non-active burrows) will be inspected. The areas surrounding these locations will also be searched to identify any new burrows in the vicinity. – All burrows present will be assessed to determine if they were recently active (evidenced by ‘fresh’ spoil, tracks, diggings and scats). – Motion sensor cameras will be used to monitor active Bilby burrows and confirm if Bilbies are present immediately prior to clearing. • In the week preceding entry of large scale mechanised equipment used for land clearing, Bilby burrows determined by pre clearance surveys to be not currently in use will be collapsed to minimise potential for use prior to land clearing, • If pre-clearance surveys indicate active burrows are within the area to be cleared, a Greater Bilby capture and relocation program will be developed and implemented by a suitably qualified environmental professional. • A suitably qualified person (fauna spotter) will be on site during land clearing. The fauna spotter will meet the following requirements: – Have appropriate training in fauna handling techniques. – Will hold a permit to handle and move significant fauna under Regulation 15 of the WC Act 1950. – Have suitable equipment to administer emergency care to injured and or displaced fauna. • Have access to a care facility that can used to rehabilitate injured fauna. • Speed limits will be implemented for operational areas and the Site Access Road. • Personnel will be required to adhere to speed limits and drive to road/weather conditions to minimise risks of fauna injuries or death due to vehicle traffic • The Site Access Road will be constructed with a 5 m buffer of cleared area on each side with topsoil stockpiles located up to 20 m away from the trafficable surface. • Travel between dusk and dawn on the Site Access Road and village access road will be limited to essential travel with driving speed limits set to reduce the potential for road strikes. • The site induction program will provide information on the Greater Bilby and the importance of minimising impacts on the species. • Sheffield will undertake pest animal control within the Mine Site Development Envelope in co-operation with regional control programs. • Domestic waste facilities will be fenced and putrescible wastes will be regularly covered. • Borrow pits will be designed and constructed to minimise permanent water ponding after rehabilitation. • Firefighting equipment will be located on site and emergency personnel will be trained in fire response • Lightning protection equipment will be installed as part of project design where necessary. • Vehicles will not be permitted to leave access tracks or cleared areas. • A Hot Work Permit system will be developed and implemented. • All machinery and vehicles undertaking clearing activities will be fitted with firefighting equipment.	The Mine Site Development Envelope is known to support Greater Bilbies. Consistent with other areas of the Dampier Peninsula, the Development Envelope will support Greater Bilbies in low densities with significant difference in population numbers at any point in time given the highly mobile nature of the species. It is almost certain that clearing associated with the project will result in loss of some Greater Bilby habitat, as well as habitat fragmentation and displacement of individuals. Habitat loss given the nature of the mining process will be progressive and is not expected to be permanent apart from expansion of the existing Mt Jowlaenga Road to form the Site Access Road. Progressive rehabilitation of mined areas to the current land use (grazing of native pasture) will minimise long term habitat loss. Extensive habitat is available in the areas surrounding the Mine Site Development Envelope and thus it is considered feasible for individual Greater Bilbies to move away from the impact area and colonise this habitat during the duration of the project. Clearing activities are also almost certain to result in the injury or death of some individual Greater Bilbies. Likewise, vehicle strike is almost certain to cause injury or mortality of some individuals. However, these injuries and mortalities are not expected to impact the ability of the Greater Bilby population to survive at the local or regional level. Light and noise pollution are likely to disrupt the nocturnal activities of the Greater Bilby, but affected individuals are expected to move away from noise and light sources. Fauna injury or mortality due to increased predation, changes to the fire regime, or entrapment may occur, however are not considered likely to impact population viability or diversity. Based on an assessment of the potential impacts on the Greater Bilby in accordance with the *EPBC Act* significant impacts guidelines it can be summarised that the project is not expected to: • Lead to a long term decrease in the size of an important population of the species. • Significantly reduce the area of occupancy of an important population. • Fragment an existing population into two or more populations. • Adversely affect habitat critical to the survival of a species. • Disrupt the breeding cycle of an important population.

Factor	EPA Objective	Existing Environment	Potential Impact	Management Measures	Predicted Outcomes
				• Sheffield will work with the pastoralist, Traditional Owners and DFES to undertake prescribed burns and install and maintain firebreaks if required so that potential environmental damage from extreme and out of control wildfires is minimised and infrastructure and the community are protected throughout the life of the project. • The project site induction will include information on the prevention and management of fires. • Travel between dusk and dawn on the Site Access Road and village assess road will be limited to essential travel. • Lights will be strategically placed and designed to shine towards plant operations and minimise light spill to the environment. • Equipment design will specify compliance with Australian Standard noise limits. • Artificial water sources will have egress points installed. • Open holes, trenches, landfill, and any water holding facilities will be inspected regularly for fauna. • Domestic waste facilities will be fenced and putrescible wastes will be regularly covered. • Rehabilitated areas will be monitored to ensure radiation levels are consistent with measured pre-mining background levels.	• Modify, destroy, remove, isolate or decrease the availability or quality of habitats to the extent that the species is likely to decline. • Result in invasive species that are harmful to the Greater Bilby becoming established. • Introduce disease that may cause the species to decline. • Interfere substantially with the recovery of the species. Sheffield is committed to managing the project such that the species would not be significantly affected. In recognition of the conservation status of the species and potential impacts on it, an offset package to mitigate impact is proposed. This is detailed in Section14.
Integrating Factor – Offsets					
Offsets	*To counterbalance any significant residual environmental impacts or uncertainty through the application of offsets.*	N/A	N/A	Specifically, in order to offset significant residual impacts of the Greater Bilby, Sheffield proposes to: • Establish the Kimberley Greater Bilby Trust. The purpose of this Trust will be to administer funds for research into the Greater Bilby. Sheffield will commit a total of $750,000 over the life of the project with 60% of Sheffield funds to be allocated for completion of projects by the end of Year 20. • Work collaboratively with other interested stakeholders to develop and implement a WA Bilby Record Database and fund administration for 10 years. Estimated costs are $40,000 for establishment in the first year and $5,000 per year for 9 years for a total of $85,000. • Provide logistical support for people undertaking relevant research projects (flights to site, accommodation, and field work assistance) for research projects. Estimated costs are $10,000 per person per project per year for a total of $90,000 based on three research projects for three year's duration each. • Feral animal control within the Mine Site Development Envelope. It is recognised the project may result in increased predator populations. Sheffield will allocate $5,000 per year for 45 years for a total of $225,000. • The offsets package proposed totals $1,150,000 over the life of the project which will generate significant positive outcomes for the Greater Bilby in the Kimberley.	The proposed offset package is designed to counterbalance the loss of Greater Bilby habitat which has the potential to occur through permanent modification of habitat characteristics in the Mine Site Development Envelope. This will be achieved by reducing threats to the Greater Bilby, potentially improving habitat condition, and increasing numbers across the broader Dampier Peninsula. Sheffield considers that the potential significant residual impacts to the Greater Bilby will be able to be counterbalanced by the proposed offsets package such that the environmental objective for offsets will be met.

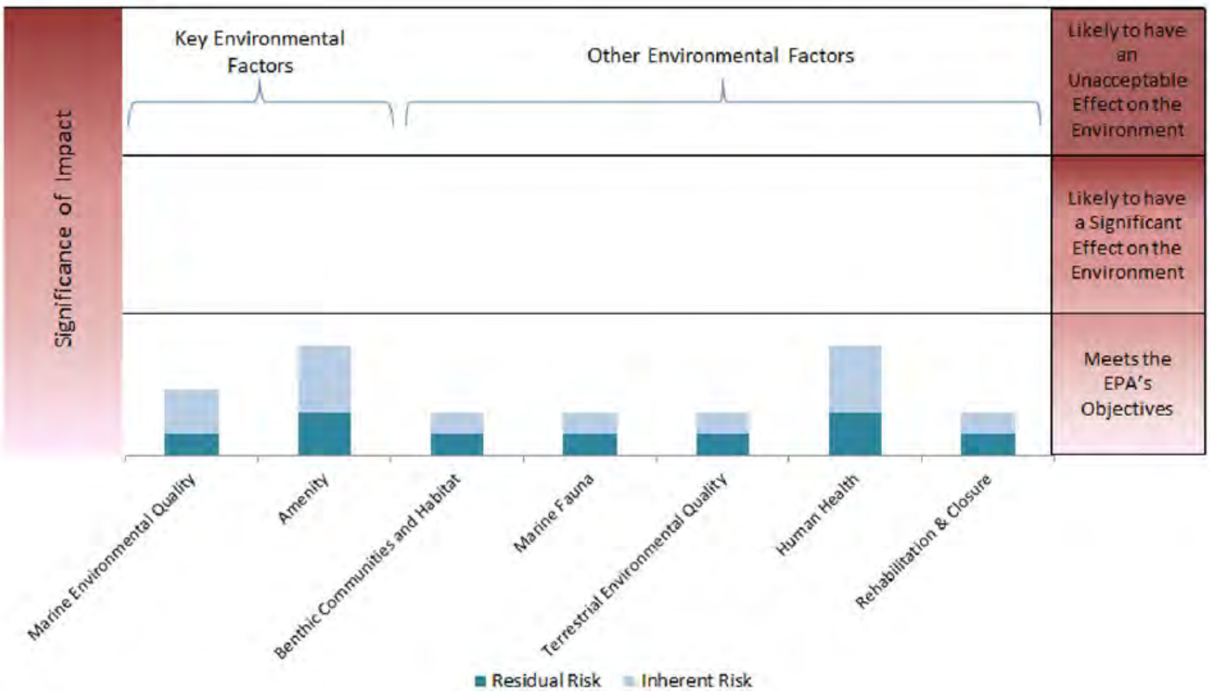
APPLICATION OF A SIGNIFICANCE FRAMEWORK

The Environmental Protection Authority applies a significance framework to the assessment of Public Environmental Reviews (EPA 2015a). An assessment of the residual and inherent potential impacts to each factor under assessment is presented below, in line with the Environmental Protection Authority approach (EPA 2015b).

Mine Site Development Envelope



Derby Port Development Envelope



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1. INTRODUCTION

1.1 PROPONENT

The Thunderbird Mineral Sands Project (the project) is a greenfield heavy mineral sands project proposed to be developed by Sheffield Resources Limited (Sheffield, or the proponent). Sheffield is a mineral sands focused explorer and developer, headquartered in Perth, Western Australia. It is listed on the Australian Securities Exchange (ASX).

The proponent can be contacted at:	Sheffield Resources Ltd Level 2, 41 - 47 Colin Street West Perth WA 6005
The key contact for the project is:	Mr Bruce McFadzean Managing Director Telephone: (08) 6555 8777 Email: info@sheffieldresources.com.au

1.2 PROJECT OVERVIEW

1.2.1 Project Summary

The project is a greenfield project and will comprise:

- Mining of heavy mineral sands over a 40 plus year period from the Thunderbird deposit. The initial rate of mining will allow excavation of a nominal 7.5 million tonnes per annum (Mtpa) of ore for the first four to five years, before increasing to a nominal 15 Mtpa of ore for the remainder of the project life.
- Onsite primary and secondary processing of ore to produce a range of saleable mineral sands products (ilmenite, primary zircon, zircon concentrate, titano-magnetite and HiTi88 Leucoxene). Construction of processing facilities will be staged with production doubled to 15 Mtpa after approximately year five.
- Abstraction and reinjection of groundwater from the Broome Sandstone Aquifer to allow mining and supply ore processing needs. As the orebody is mined, there will eventually be a positive water balance (more water being pumped from the pit than can be used in processing) so that a portion of the extracted water will be re-injected into the Broome Sandstone Aquifer downstream of mining operations.
- Development of infrastructure to support the project including power generation facilities, accommodation village, administration and maintenance buildings, internal roads, communications infrastructure, and waste storage and disposal facilities.
- Upgrade and extension of the existing pastoral road (Mt Jowlaenga Road) from the Great Northern Highway to form a 30 km Site Access Road.
- Transport of mineral sands products from the Mine Site via the Site Access Road and Great Northern Highway to Derby or Broome Ports for storage prior to export.
- Export of bulk mineral sands products from Derby Port via King Sound and packaged mineral product from Port of Broome to international customers.

Construction of the project is scheduled to commence in Quarter 3 2017, with mining and production scheduled to commence in early 2019. The project will be fully operational in early 2019 with the first export of product anticipated by end of 2019.

The project is considered in terms of two separate Development Envelopes; Mine Site and Derby Port. These will contain the majority of project-related activities and will both require construction of new infrastructure. Whilst export of packaged mineral sands products will also occur from the Port of Broome, this will use existing facilities and no changes are required to allow the project to use this infrastructure. As such, the Port of Broome has not been considered as a Development Envelope.

1.2.2 Location

The project is located on the Dampier Peninsula within the west Kimberley region of Western Australia (Figure 1). The project comprises two geographically separate locations, namely the Mine Site Development Envelope (including the Site Access Road) (Figure 2) and the Derby Port Development Envelope (Figure 3). There are no other mining projects located on the Dampier Peninsula. The nearest mines are the Koolan Island iron ore mine located offshore approximately 200 km northeast of the project, and Ellendale diamond mine located approximately 200 km east of the project, both of which are temporarily suspended (Geoscience Australia 2016). Derby Port is an operational port and has been previously used for export of mineral products but is currently not being used for this purpose. Derby Port is located in King Sound, which is currently home to several aquaculture and pearling enterprises.

The Mine Site Development Envelope is located approximately 75 km west southwest of Derby and 95 km northeast of Broome (Figure 1). It is accessed from the Great Northern Highway via a proposed 30 km long Site Access Road.

The Mine Site Development Envelope is located within Mt Jowlaenga Pastoral Lease (H910623), held by the Yeeda Pastoral Company Pty Ltd. An existing pastoral road that connects the Great Northern Highway to the abandoned Mt Jowlaenga Homestead will be upgraded to form part of the Site Access Road for the project. The Site Access Road intersects the Great Northern Highway approximately half way between Broome and Derby; the intersection is approximately 110 km to Derby and 100 km to Broome by road.

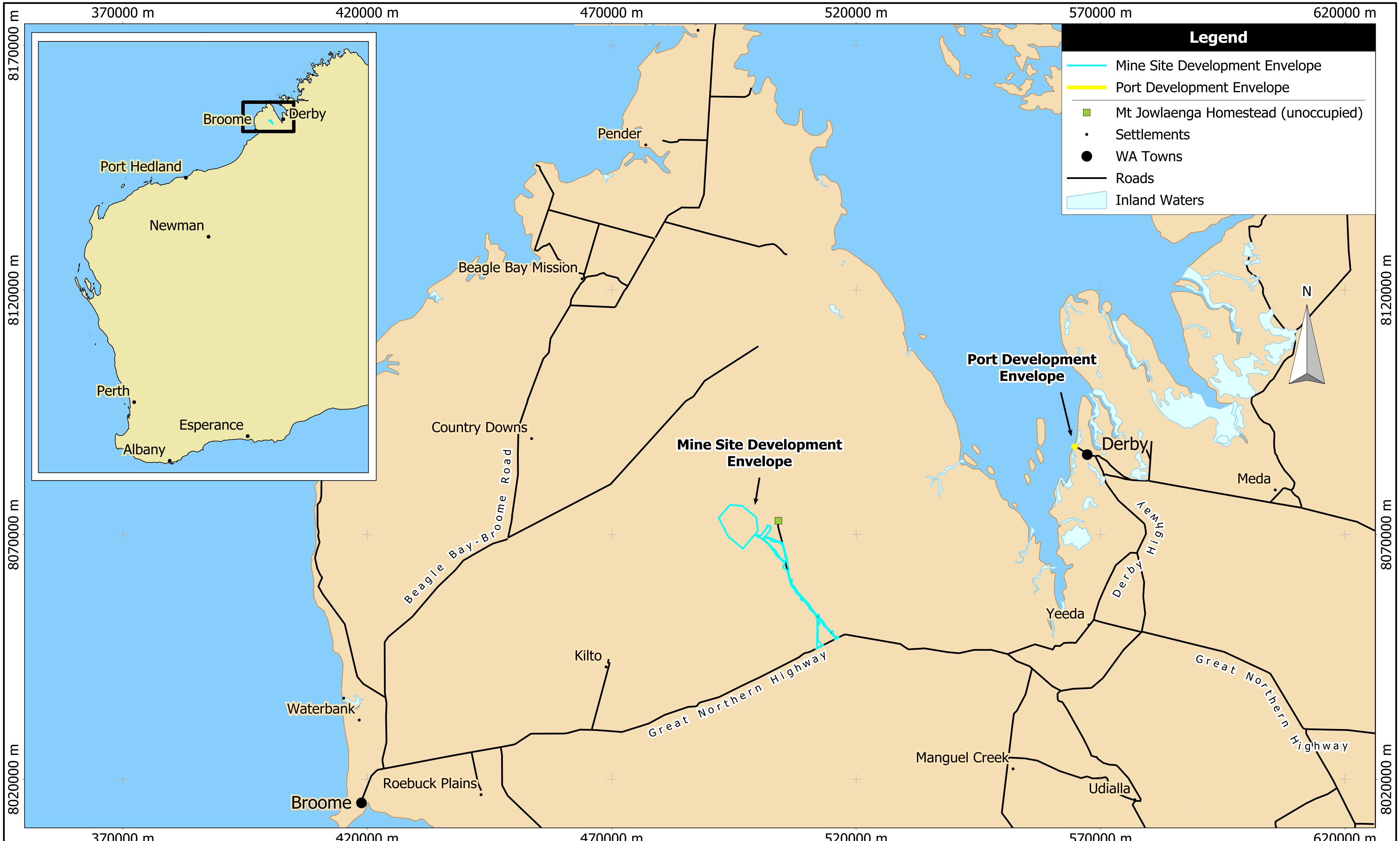
Several tenements are held by Sheffield for the Mine Site components of the project; these are detailed in Table 1 and shown in Figure 2.

Table 1: Thunderbird Mineral Sands Project Tenements

Tenement	Area (hectares)	Holder	Granted	Expiry
M04/459	4,525	Sheffield Resources Pty Ltd	Pending	N/A
L04/82	633	Sheffield Resources Pty Ltd	Pending	N/A
L04/83	219	Sheffield Resources Pty Ltd	Pending	N/A
L04/84	120	Sheffield Resources Pty Ltd	23/04/2015	22/04/2036
L04/85	237	Sheffield Resources Pty Ltd	23/04/2015	22/04/2036
L04/86	191	Sheffield Resources Pty Ltd	23/04/2015	22/04/2036

Bulk mineral sands products will be transported by road from the Mine Site to Derby Port, located 2 km northwest of the Derby township, where they will be stored prior to export. A Product Storage Facility will be located at the Port adjacent to the existing wharf facility and is accessed via a manmade causeway (Jetty Road) that traverses the mudflats of King Sound (Figure 3). Smaller volumes of packaged product will be exported from the Port of Broome using existing facilities. No additional development of facilities is proposed for the Broome Port.

The storage facility at Derby Port will be located on the site of a previous mineral product export storage facility. Product will be transferred from the storage facility to dedicated transhipment vessels via a covered transhipment vessel loading conveyor. Transhipment vessels will then transfer product for 33 km to ships at a dedicated sea transfer point. Existing port infrastructure will be used with minor improvements made as required.



Scale: 1:1000000
Original Size: A4
Grid: MGA94(51)

0 40 km

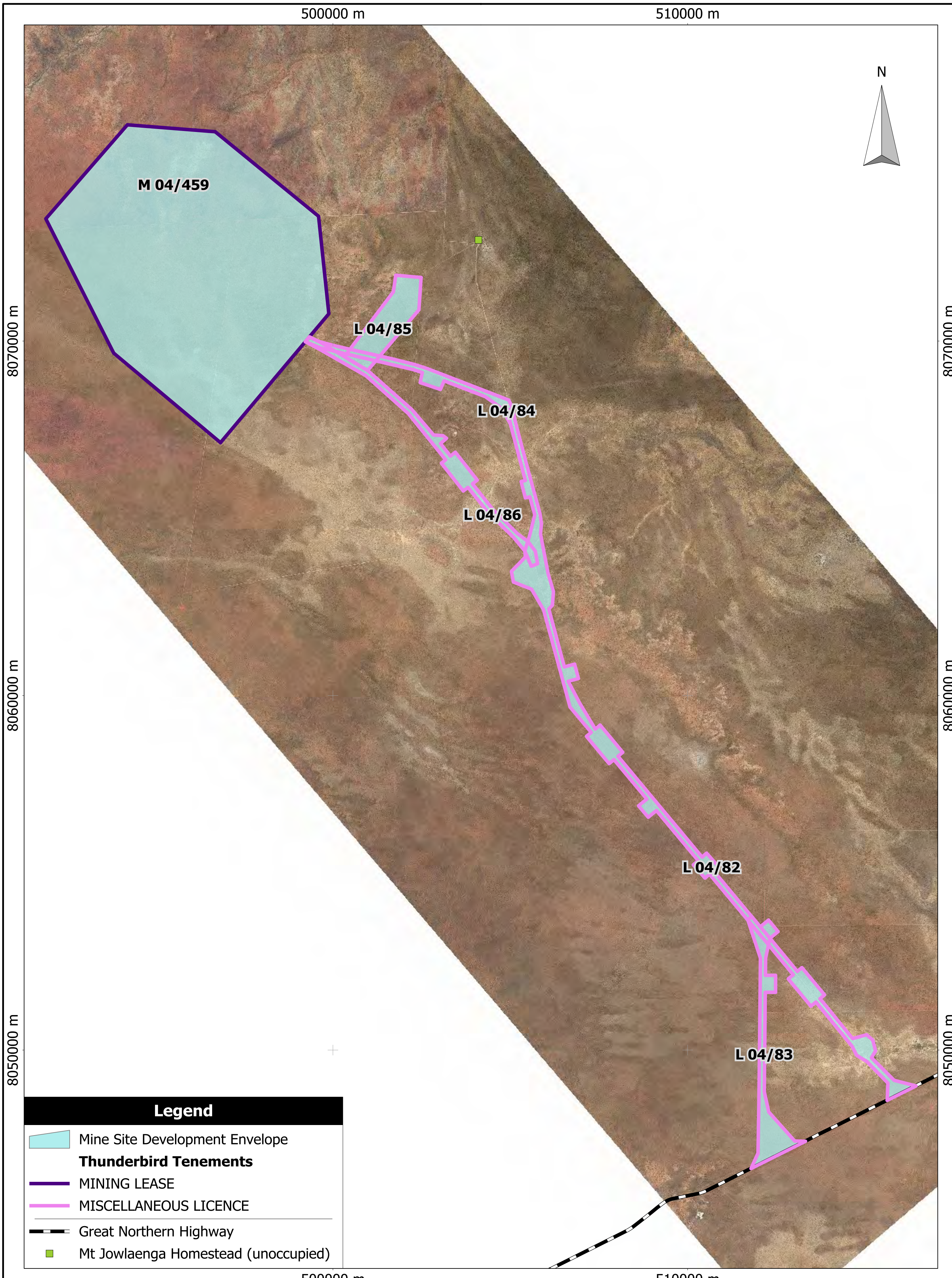
Sheffield Resources Limited
Thunderbird Mineral Sands Project

Figure 1

Project Location

4 Cook St
West Perth WA 6005
Ph: (08) 9226 3166
Fax: (08) 9226 3177
info@mbsenvironmental.com.au
www.mbsenvironmental.com.au
MBS ENVIRONMENTAL

W:\Sheffield Resources\PER\Drawings\PER Location Plan.map 11/11/2016 F1 Project Location Layout



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Original Size: A4
Air Photo Date: 2015
Grid: Australia MGA94 (51)
0 4 km

Sheffield Resources Limited
Thunderbird Mineral Sands Project

Figure 2

Mine Site Development Envelope and Tenements

Martinick Bosch Sell Pty Ltd
4 Cook St
West Perth WA 6005
Ph: (08) 9226 3166
Fax: (08) 9226 3177
info@mbsenvironmental.com.au
www.mbsenvironmental.com.au

W:\Sheffield Resources\PER\Drawings\PER Map.map 11/11/2016 F2 Mine Site Development Envelope and Tenements Layout

Scale: 1:20000
Original Size: A4
Image: Landgate Locate WA
Grid: Australia MGA94 (51)

Sheffield Resources
Thunderbird Mineral Sands Project

Figure 3

Port Location Plan

4 Cook St
West Perth WA 6005
Ph: (08) 9226 3166
Fax: (08) 9226 3177
info@mbsenvironmental.com.au
www.mbsenvironmental.com.au

1.2.3 Justification and Objectives

Sheffield is a mineral exploration company with extensive tenure throughout Western Australia, including the Dampier Peninsula. In September 2011, Sheffield was granted an Exploration Licence E04/2083 covering the Thunderbird deposit. With development of the project, the proponent will transition into a production/mining company.

The Thunderbird deposit was discovered by Sheffield in 2012, following earlier exploration by Rio Tinto Exploration Pty Ltd between 2003 and 2009. Using drilling and analysis, Sheffield defined a mineral resource and ore reserve. This information was used as part of the Pre-Feasibility Study, completed in December 2015.

The objective of the project is to establish an operating mineral sands mine and processing facilities with supporting infrastructure and services for production and export of heavy mineral sands products including ilmenite, primary zircon, zircon concentrate and HiTi88 Leucoxene. A by-product, titano-magnetite, may also be sold. These mineral products constitute about 5% of the ore, with the remaining 95% returned to the mining void after processing. This is driven by worldwide need for ceramics, paint and other commonly used materials that contain these heavy minerals.

Heavy mineral sands are an important ingredient in many everyday products and the project represents an opportunity for Western Australia to benefit from the development of this resource. The project will have a positive impact on the Kimberley region over an extended period. The project will create employment opportunities for local Indigenous and non-Indigenous people, and create opportunities for local Indigenous and non-Indigenous businesses. The project will also add to scientific knowledge through ongoing monitoring of the environment. Specifically, the project will:

- Create 140 permanent local jobs as well as opportunities for partnerships with Indigenous businesses.
- Produce an important product used in everyday items such as toothpaste, artificial joints, crockery, tiles and porcelain, paint, food colouring, medicines, and sunscreen.
- Have a long intergenerational life of greater than 40 years.
- Provide increased direct and indirect business opportunities in Broome and Derby through operation of the mine and shipping activities.

1.2.4 Alternatives

The project will provide 140 local jobs for more than 40 years and will provide economic benefits to the Kimberley region and the State. It is amongst the world's largest mineral sands deposits discovered in the last 30 years, and is the largest discovery of zircon in the last 30 years. If the project was not developed, economic and social benefits to the State, Kimberley region, local businesses and Traditional Owners would not be realised.

Several alternative project options were considered during the preliminary and bankable feasibility studies, planning, and design processes. Key alternative options considered and/or implemented and the change to the impact on the environment of the project as a result is detailed in the following sections. These alternatives were considered as implementation, design, temporal, or spatial considerations.

1.2.4.1 Mining

The Thunderbird deposit is proposed to be mined using a conventional dry mining approach which is used successfully in Western Australia for several projects. The dry mining method allows for minimal disturbance at any given time, and progressive backfill of the mining excavation and is the most appropriate mining method for the project. The location of the ore reserve cannot be changed and as such the overall location of the mineral deposit area is fixed, however alternatives were considered for the following aspects:

- **Mining method** (implementation consideration) – Wet (dredge) mining was considered during the feasibility and design process, however was not considered feasible due to the slime content of the ore and large capital cost of a dredge.

- **Mining Rate** (temporal consideration) - Sheffield modelled various mining rates during Scoping and Pre-Feasibility studies, and the scale of the mining and processing operations in terms of capital and operating costs and production impacts on the mineral sands markets. The decision to adopt an ore mining rate of 7.5 Mtpa for the first 4 years, then ramping up to 15 Mtpa after that over a period of more than 40 years was considered and is proposed. This will:
  - Reduce water requirements and aquifer recovery time.
  - Extend the life of the project and the benefits to the region.
  - Reduce the area of clearing required annually and the amount of land under rehabilitation at any given time.
  - Reduce capital costs, and potential adverse impacts on the market.
- **Mining excavation footprint** (spatial consideration) - The mining footprint has been reduced from the original proposed footprint to maintain an adequate buffer for identified Aboriginal Heritage sites. The heritage buffers have been defined by Traditional Owners over the past five years and therefore are a result of extensive consultation.

1.2.4.2 Ore Processing

Alternatives considered included processing methods and locations such as primary and/or secondary processing offsite. These include specifically:

- **Offsite Processing** (spatial consideration):
  - Primary processing on site and secondary processing offsite was considered to potentially reduce the impact of air emissions generated by secondary processing on the surrounding environment, however, the remote location of the project is considered as a buffer to sensitive receptors.
  - The location of the processing plant components has been optimised to reduce the capital cost, and thus footprint of the project. The initial processing stage Mining Unit Plants are located within the mining excavation and thus no additional land clearing is required for this equipment. These units are skid-mounted and will be relocated as the mining excavation advances.
- **Annual Throughput** (temporal consideration): As discussed in Section 3.3 the proposed ore processing throughput was originally 12 Mtpa at start-up then increased to 18 Mtpa at Year 7, but was reduced to an initial start-up rate of 7.5 Mtpa increasing to a maximum of 15 Mtpa in Year 4 to 5 of the project. This reduced throughput:
  - Reduces annual water requirements and aquifer recovery time.
  - Extends the life of the project and the benefits to the region.
  - Reduces the area of clearing required annually and the amount of land under rehabilitation at any given time.
- **Processing method** (design consideration): Several alternatives to the processing method have been considered throughout the feasibility and design process. Some of the changes made to the process method are listed below:
  - Low temperature roasting and magnetic fractionation was added to the process to lower the iron content of the primary ilmenite product, and increase the TiO2 grade. This step adds value to the product on-site, as opposed to a similar process taking place off-shore, thereby maximising benefits to the State.
  - Hot acid leach process on the non-magnetic fraction of the Heavy Mineral Concentrate (HMC), and screening and scrubbing of oversize added to improve the separability and recovery (increased quality) of final products from the zircon process.

- Design changes to reduce water use and increase water recovery and recycling. For example, approximately 50% of water from the co-disposal stream will be reclaimed and reused.
- Creation of alternative secondary products and/or concentrates previously produced as a waste stream (e.g. zircon concentrate derived from primary zircon and HiTi Process streams).

1.2.4.3 Process Water Sources

A large borefield was originally proposed south of (and external to) the mining lease to supply make-up water prior to mining below the water table. Investigations to improve the efficiency of water use in processing, along with a reduced mining rate (Section 3.3), mean that a smaller borefield is more appropriate. Make-up water will now be sourced from a smaller borefield located within the mining lease.

1.2.4.4 Mine Dewatering

Surface discharge, and/or storage and evaporation of excess water were considered as alternatives to the current proposal of reinjection back into the aquifer when this is required. Surface discharge and storage/evaporation would result in a larger disturbance footprint and greater water loss through evaporation potentially resulting in an extended aquifer recovery time. Reinjection of excess water is anticipated to assist the aquifer to recover more readily.

1.2.4.5 Site Access

Several different routes were considered for the Site Access Road. This included:

- Using the existing roads only (Mt Jowlaenga Road and Station tracks).
- Using the existing road with modifications.
- Building a completely new access road.

Using the existing Mt Jowlaenga Road with modifications was selected as the most cost effective, and environmentally and socially beneficial option. Baseline surveys were conducted to assist in selecting the proposed road alignment, which included consideration of the following:

- Avoiding water courses and low-lying areas likely to be subject to inundation during the wet season, minimising the need for engineered crossings.
- Avoiding known locations of Bilbies.
- Avoiding heritage areas and any associated buffers.
- Minimising additional land use and thus vegetation disturbance.
- Minimising disruption to pastoral activities undertaken at Mt Jowlaenga Station, including minimising traffic passing near the Mt Jowlaenga Homestead.
- Maximising line of sight, minimising blind corners, and minimising areas of difficult terrain for road user safety.
- Maximising proximity to potential water resources to allow use of a single corridor for vehicle access and water transfer to the mining and ore processing areas, and associated support facilities.
- Designing a safe intersection with the Great Northern Highway.
- Reduction in product haulage vehicle emissions.

1.2.4.6 Transport and Shipping

A summary of alternatives considered for transport and shipping for the project are detailed below. Alternatives with the least impact on the environment and amenity were incorporated into the project:

- Smaller trucks (triple road trains) were considered to minimise amenity impacts in Derby, however by using quad road trains, the number of truck movements is significantly reduced, which will reduce the impacts on amenity from transport of product.

- Potential to load the mineral sands products at Derby Port via a lock system constructed and operated by a third party was considered. As the lock system is currently in the scoping stage, there is no guarantee the system will be constructed and available for use once export of mineral sand product commences. Therefore, for the proposed project to be feasible, existing options have been selected (transhipment vessel loading system).
- Potential alternatives to bulk product export via Derby Port included export via Broome Port. Export of bulk produce via Derby Port and export of packaged product via the Port of Broome was found to be the preferred option. Key reasons for this selection are:
  - Derby Port has existing transhipment vessel loading infrastructure suitable for a bulk product loading that can be used by Sheffield, meaning lower construction requirements.
  - Derby Port has space to accommodate building of a product storage shed or silos for storage of bulk product and can be connected to the existing loading conveyor.
  - Derby Port is located about 2 km away from residential areas meaning there is a significant buffer distance for any potential noise and air emissions.
  - Derby Port has greater capacity to accommodate the planned shipping arrangements compared to the Port of Broome.
  - Derby Port does not have infrastructure to allow efficient transfer of packaged products from the wharf to barges.
  - The Port of Broome has existing storage sheds and transfer infrastructure to allow storage and transfer of packaged products to an ocean-going vessel which can moor at the wharf. No additional infrastructure would be required to allow use of the Port of Broome.
  - Road infrastructure to access the Port of Broome was upgraded as part of the Royalties to Region Scheme to bypass residential and commercial areas of Broome. Use of the bypass will minimise amenity impacts on residents.
  - The Port of Broome does not currently have infrastructure to allow for the bulk loading of product to marine vessels.
  - The Port of Broome is currently underutilised and has significant capacity to accommodate Sheffield's proposed use whilst still allowing for other potential future users.
- Transport of ore to other ports was considered cost prohibitive due to transport costs and lack of existing infrastructure.
- Transport options include shipping in bulk or using 'break bulk' logistics and shipping in smaller packages. Break bulk logistics will be carried out at the Mine Site.
- A potential increase in capacity of the ship loading conveyor could be carried out if required in consultation with Shire of Derby/West Kimberley.

1.3 PURPOSE AND SCOPE

The project was referred to the Western Australian Environmental Protection Authority (EPA) by the Proponent on 20 November 2015. On 21 December 2015, the level of assessment was set as Public Environmental Review (PER) with a four week public review period.

The project was referred to the (then) Commonwealth Department of the Environment (now named the Department of Environment and Energy), and on 7 April 2016 it was determined to be a Controlled Action under the *Environment Protection and Biodiversity Conservation Act 1999* (*EPBC Act*). This project is being assessed under the Bilateral Agreement between the Commonwealth of Australia and the State of Western Australia, made under Section 45 of that Act.

An Environmental Scoping Document (ESD) was prepared by the Proponent to address Commonwealth and State impact assessment requirements. This was approved by the EPA and released as final on 5 July 2016. The ESD outlines the preliminary key environmental factors and work requirements for inclusion in the PER.

During preparation of the Bankable Feasibility Study, a number of additional technical studies provided greater clarity on project design. This allowed refinement of project key characteristics since submission of the ESD. The most significant changes comprised additions to product exporting plans to include export of packaged products through the Port of Broome, an increase in project power generation requirements, clarification of groundwater abstraction volumes over the 40+ year project life and minor changes to the total amount of land clearing required. Sheffield subsequently submitted a request to change the relevant key characteristics of the proposal under Section 43A of the *Environmental Protection Act 1986* (*EP Act*) in November 2016. These changes were deemed by the EPA to be unlikely to significantly increase any environmental impact of the project. As such, updates have been made to incorporate these project changes into the environmental impact assessment in this PER. The Section 43A application and approval letter are provided in Appendix 1.

This PER has been prepared to fulfil the requirements for assessment of the project pursuant to Part IV of the Western Australian *EP Act* and relevant requirements of the *EPBC Act* and Schedule 4 of the *Environment Protection and Biodiversity Conservation Regulations 2000*.

This PER has been prepared in accordance with the *EP Act Environmental Impact Assessment - Administrative Procedures 2012*, the OEPA Guidelines for Preparing a Public Environmental Review (2015), the ESD, Section 43A application and the checklist for documents submitted for Environmental Impact Assessment (Appendix 2).

1.4 ENVIRONMENTAL COMMITMENT

Sheffield's Environmental Policy outlines its intentions and commitment to environmental performance as a company and to the project specifically. Sheffield's Environmental Policy is provided in Appendix 3.

Sheffield is developing an environmental management system (EMS) to facilitate the management of environmental responsibilities for all phases of the project (construction, operation, and closure), and to enable continuous improvement of the proponent's environmental performance. Over the life of the project, the EMS will enable Sheffield to systematically assess and review its environmental impacts and obligations, and implement programs for their management.

The Sheffield EMS will be based on AS/NZ ISO 14001:2004 Environmental Management System Standards, which are internationally accepted and include a model for continuous improvement.

Environmental Management Plans will form the cornerstone of the project's EMS as they will document actions and responsibilities for protection of the conservation values of the project.

1.5 DOCUMENT STRUCTURE

The PER is structured to meet the requirements of the EPA Guidelines for Preparing a Public Environmental Review (EPA 2015a). An overview of the key sections of the PER is provided in Table 2.

Table 2: PER Sections Summary

No.	Heading	Description
1	Introduction	Introduction to the project, including the location, objectives, purpose and scope and the proponent's commitment to environment.
2	Legislative Framework	Summary of applicable legislation and management of the project within the Commonwealth and State legislative framework.
3	Project Description	Detailed description of the project, including mining, processing, waste management, water requirements, land use, and other key mine site infrastructure. Transport and export of product are described, as well as closure and rehabilitation of the site at cessation of mining.
4	Existing Environment	Detailed description of the existing environment at the Mine Site and Derby Port Development Envelopes including geology, soils, hydrogeology and hydrology, flora and vegetation, terrestrial and subterranean fauna, land use, heritage, and amenity.
5	Environmental Management Framework	Description of the Environmental Policy, EMS, and EMPs for the project. Sheffield's commitment to the EPA's Principles of Environmental Protection is detailed in this section.
6	Community and Stakeholder Consultation	Overview of stakeholder and community consultation plan, consultation carried out to date, and issues raised and resolved.
7	Assessment Method	Description of the systematic approach that has been used to identify and assess potential impacts and to determine the mitigation and management measures required to prevent or minimise potential impacts.
8	Environmental Impact Assessment - Key Environmental Factors - Mine Site Development Envelope	Detailed environmental impact assessment for each key factor for the Mine Site Development Envelope including statutory requirements, assessment of potential impacts, management measures, and predicted outcome in terms of achievement of the EPA objectives for each factor.
9	Environmental Impact Assessment - Key Environmental Factors - Port Development Envelope	Detailed environmental impact assessment for each key factor for the Derby Port Development Envelope including statutory requirements, assessment of potential impacts, management measures and predicted outcome in terms of achievement of the EPA objectives for each factor.
10	Environmental Impact Assessment - Other Environmental Factors - Mine Site Development Envelope	Detailed environmental impact assessment for each 'other' factor for the Mine Site Development Envelope including statutory requirements, assessment of potential impacts, management measures, and predicted outcome in terms of achievement of the EPA objectives for each factor.
11	Environmental Impact Assessment - Other Environmental Factors - Port Development Envelope	Detailed environmental impact assessment for each 'other' factor for the Derby Port Development Envelope including statutory requirements, assessment of potential impacts, management measures, and predicted outcome in terms of compliance with EPA objectives for each factor.
12	Environmental Impact Assessment - Integrating Factor - Rehabilitation and Decommissioning	A description of policies, potential impacts, management measures and predicted outcomes in terms of compliance with the EPA objectives for the integrating factor related to rehabilitation and closure.
13	Environmental Impact Assessment - Matters of National Environmental Significance	Detailed description of Matters of National Environmental Significance within the Mine Site Development Envelope, assessment of potential impacts, management measures and predicted outcomes.
14	Environmental Impact Assessment - Integrating Factor - Offsets	A description of offset policies, mitigation sequence, and significant residual impacts is provided along with requirements for offsets as assessed against Commonwealth and State offset assessment tools and the offset strategy.
15	References	Detailed list of references used in preparation of the PER.

2. LEGISLATIVE FRAMEWORK

The Thunderbird Mineral Sands Project is subject to both Australian (Commonwealth) and Western Australian legislation. This section provides a summary of the Commonwealth and State statutory requirements relating to the construction, development, and operation of the project.

2.1 ENVIRONMENT PROTECTION AND BIODIVERSITY CONSERVATION ACT 1999

The Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (*EPBC Act*) is administered by the Commonwealth Department of the Environment and Energy (DoEE). Commonwealth approval is required if Matters of National Environmental Significance (MNES), as defined in the *EPBC Act*, are potentially impacted, including migratory birds, listed rare flora, fauna, or Threatened Ecological Communities, listed heritage sites or Commonwealth marine areas, Commonwealth land, Commonwealth activities, and nuclear actions.

Submission of a referral to DoEE using the prescribed form is required to have formal determination of whether a project is a Controlled Action. If MNES are likely to be impacted, a proposal will be deemed to be a Controlled Action and Commonwealth project approvals may be required. If the project is determined to be a Controlled Action under the Bilateral Agreement, the WA Environmental Protection Authority (EPA) referral process can inform DoEE and a separate Commonwealth assessment is not required.

The project was referred to the (then) Department of the Environment on 8 February 2016 under the *EPBC Act* and was deemed to be a 'Controlled Action' on 7 April 2016 in respect to impacts on listed threatened species, specifically the Greater Bilby (*Macrotis lagotis*). The project is to be assessed consistent with the provisions of the Bilateral Agreement.

2.2 NATIVE TITLE ACT 1993

Native Title recognises the traditional rights and interests to land and waters of Aboriginal and Torres Strait Islander people. Under the Commonwealth *Native Title Act 1993* (*NT Act*), Native Title claimants can make an application to the Federal Court to have their Native Title recognised by Australian law.

The *NT Act* sets up processes to determine where Native Title exists, how future activity impacting upon Native Title may be undertaken, and to provide compensation where Native Title is impaired or extinguished. The *NT Act* gives Indigenous Australians who hold Native Title rights and interests, or who have made a Native Title claim, the right to be consulted and, in some cases, to participate in decisions about activities proposed to be undertaken on the land.

The mining lease is located within the Mt Jowlaenga Polygon #2 (Native Title Claim WC2014/005 registered on 15/12/2014) and the southern parts of the Site Access Road are located within the Nyikina Mangala Consent Determination Area (National Native Title Tribunal Reference Number WCD2014/003).

Sheffield is seeking an agreement with the Mt Jowlaenga Polygon #2 Claimant Group to facilitate granting of M04/459. This agreement provides for the Claimant Group's input into cultural awareness programs, cultural and environmental management and monitoring, as well as for employment and contracting opportunities in addition to upfront and production-based payments. Sheffield has also consulted with Native Title parties and Traditional Owners whose interests may be affected by the Miscellaneous Licences covering the Site Access Road.

2.3 ENVIRONMENTAL PROTECTION ACT 1986

The Western Australian *Environmental Protection Act 1986* (*EP Act*) is the primary legislation governing environmental protection and impact assessment in the state. Approvals can be required under two parts: Part IV and Part V. Projects with the potential to significantly impact on the environment, or of sufficient public interest, are assessed under Part IV. Facilities that may constitute a 'prescribed premises' (as listed under Schedule 1 of the *Environmental Protection Regulations 1987*) must be approved under Part V.

The project requires assessment and approval under both Part IV and Part V of the *EP Act*.

2.3.1 Part IV - Environmental Impact Assessment

The EPA undertakes the environmental impact assessment (EIA) of some proposals referred to it under Part IV of the *EP Act*. EIA is an orderly and systematic process for evaluating a proposal (including its alternatives) and its effects on the environment. The EIA process is guided by the *EP Act* and supporting guidance material. Relevant policies and other guidance are listed in Section 2.11. The assessment includes considering ways in which the proposal, if implemented, could avoid, reduce and ameliorate the impacts on the environment.

The EPA can decide to formally assess a proposal at either of the following two levels of assessment will:

- Assessment on Proponent Information (API) - proposals where the environmental acceptability (API Category A) or unacceptability (API Category B) is apparent at the referral stage.
- Public Environmental Review (PER) - proposals where:
  - The proposal is of regional and/or State-wide significance.
  - The proposal has several key environmental factors or issues.
  - Substantial and detailed assessment of the proposal is required to determine whether, and if so, how the environmental issues could be managed.
  - The level of public concern about the likely effect of the proposal, if implemented, on the environment, warrants a public review period.

The project was referred to the EPA on 20 November 2015. On 21 December 2015, in accordance with the procedures set out in the EPA Administrative Procedures, the EPA determined that the proposal requires assessment at PER level.

2.3.2 Part V - Environmental Regulation

Under Part V of the *EP Act,* Works Approvals and Environmental Licences are required for a range of activities prescribed within Schedule 1 of that Act. Works Approvals and Environmental Licences are required from Department of Environment Regulation (DER) to allow construction and operation of key infrastructure (respectively) used for pollution control management including ore processing plants, water transfer infrastructure, water holding dams, power generation facilities, and waste treatment and disposal facilities (i.e. tailings storage facilities, landfill and sewage treatment plants). An Environmental Licence is required for operation of the project's Processing Plant, Tailings Storage Facility, landfill, and sewage treatment plant.

Conditions of Works Approvals relate to key pollution control aspects such as dust management, surface water management, seepage management, waste management, and hazardous materials containment. Compliance with conditions is required to be reported to DER before final approval is granted for the commissioning and operation of the infrastructure. Submission of compliance information can be staged to allow phased commissioning and operation of specific infrastructure.

DER is making significant changes to the Works Approval and Environmental Licencing processes. Proponents are now able to make a single application for a Works Approval and Environmental Licence, with the

Licence being formally granted on provision of proof that construction completed compliant with Works Approval conditions.

Operations that will trigger a Prescribed Premise category and require a Works Approval and Environmental Licence for the project to be issued by DER are detailed in Table 3.

Table 3: Thunderbird Mineral Sands Project Prescribed Premise Categories

Cat. No.	Category Description	DER Prescribed Premise Threshold	Relevant Project Infrastructure
06	Mine dewatering: premises on which water is extracted and discharged into the environment to allow mining of ore.	50,000 t or more per year.	Mineral deposit dewatering
08	Mineral sands mining or processing: premises on which mineral sands ore is mined, screened, separated or otherwise processed.	5,000 t or more per year.	Mining excavation, processing plant, Tailings Storage Facility and tailings pipelines.
52	Electric power generation: premises (other than premises within category 53 or an emergency or standby power generating plant) on which electrical power is generated using a fuel.	20 MW or more in aggregate (using natural gas), 10 MW or more in aggregate (using a fuel other than natural gas).	Power generation
54	Sewage facility: premises - (a) on which sewage is treated (excluding septic tanks); or (b) From which treated sewage is discharged onto land or into waters.	100 m^3 or more per day.	Wastewater treatment plants.
58	Bulk material loading or unloading: premises on which clinker, coal, ore, ore concentrate or any other bulk granular material (other than salt) is loaded onto or unloaded from vessels by an open materials loading system.	100 tonnes or more per day	Loading to transhipment vessels and transhipment
64	Class II or III putrescible landfill site: premises on which waste (as determined by reference to the waste type set out in the document entitled *"Landfill Waste Classification and Waste Definitions 1996"* published by the Chief Executive Officer and as amended from time to time) is accepted for burial.	More than 20 t per year.	Landfill facility.
73	Bulk storage of chemicals, etc.: premises on which acids, alkalis or chemicals that - (a) contain at least one carbon to carbon bond; and (B) are liquid at STP (standard temperature and pressure), are stored.	1,000 m^3 in aggregate.	Power plant, Processing plant.

2.3.3 Native Vegetation Clearing Permit

Native Vegetation Clearing Permits are required under the *EP Act*, prior to undertaking clearing of native vegetation. The granting and administration of these permits are regulated under the *Environmental Protection (Clearing of Native Vegetation) Regulations 2004*. Clearing Permits can be obtained from the Department of Mines and Petroleum (DMP) Environment Management Branch. Agreement exists between DMP and DER for DMP to assess land clearing applications related to mining activities.

A Clearing Permit is not required as the project is formally assessed under Part IV of the *EP Act*.

2.4 MINING ACT 1978

The DMP is the lead government agency with regards to approvals for mining operations in Western Australia. The *Mining Act 1978* requires that, to conduct mining activities (as defined under the Act); a Mining Proposal is to be submitted to DMP, who assess and assign environmental conditions to the project if it is to be approved.

In May 2016 DMP released updated Mining Proposal Guidelines from the previous 2006 guidelines, and as of 1 January 2017, Mining Proposals for new projects are required to conform to the new guidelines. Given the timing of the PER submission for the project, and statutory consultation and determination periods, the Mining Proposal will be submitted in 2017 hence the Mining Proposal will follow the 2016 guidelines.

Mining Proposals are also required to include a Mine Closure Plan (MCP) compliant with the joint DMP/EPA Guidelines for Preparing Mine Closure Plans (May 2015). This is assessed as part of the Mining Proposal assessment process and reviewed every three years. Mining Proposals can only be approved where Mining Lease, General Purpose Lease and or Miscellaneous Licence tenements have been granted.

Following assessment of the Mining Proposal by the DMP, several conditions will be applied on the relevant tenements, including the provisions of the Mining Proposal. All environmental commitments made in a Mining Proposal become legally binding obligations once the Mining Proposal is imposed as a tenement condition.

2.5 MINE REHABILITATION FUND ACT 2012

In 2013, DMP introduced the Mining Rehabilitation Fund (MRF); a new financial assurance system which replaced the long standing bond system. The MRF is enacted under the *Mining Rehabilitation Fund Act 2012*, which provides for the establishment of the MRF, the declaration of abandoned Mine Sites, a levy payable in respect of mining authorisations and other related matters. The *Mining Rehabilitation Fund Regulations 2013* deal with matters around the practical operation of the scheme and specify how the rehabilitation levy will be calculated.

All tenement holders operating on *Mining Act 1978* tenure are required to report disturbance data and contribute annually to the fund. Tenements with a rehabilitation liability estimate below a threshold of $50,000 are required to report disturbance data, but are not required to pay into the fund. Levies paid into the MRF will be used for rehabilitation where an operator fails to meet rehabilitation obligations. This provides confidence to the State and the community that satisfactory closure and rehabilitation of Mine Sites in West Australia will be achieved and that tenement owners will bear the cost, not the State.

In accordance with MRF legislation, Sheffield will be required to assess areas and categorise disturbance types on all project tenements within each reporting period and determine and pay the required levy.

2.6 RIGHTS IN WATER AND IRRIGATION ACT 1914

The Western Australian *Rights in Water and Irrigation Act 1914* (*RIWI Act*) addresses rights in water resources; makes provision for the regulation, management, use and protection of water resources; provides for irrigation schemes, and for related purposes. The Department of Water (DoW) administer the *RIWI Act.* Significant consultation has been undertaken with DoW and will continue throughout the assessment process and life of the project.

An application for a Groundwater Licence under section 5C of the *RIWI Act* has been made to DoW for abstraction of groundwater from the Broome Sandstone Aquifer required for the project. Permits to construct and/or alter wells (Section 26D of *RIWI Act*) will also be obtained from DoW as required.

Water abstraction and use under the licence will be managed and monitored according to an approved Groundwater Operating Strategy to assure that environmental values including vegetation and features of cultural significance are appropriately protected from the impacts of abstraction. Monitoring will incorporate abstraction volumes, levels and quality at the mine and borefields, and while this is primarily for operational purposes, the data collected will also be relevant to closure (Section 4.2.5).

2.7 ABORIGINAL HERITAGE ACT 1972

The West Australian *Aboriginal Heritage Act 1972* (*AH Act*) makes provision for 'the preservation on behalf of the community of places and objects customarily used by or traditional to the original inhabitants of Australia or their descendants, or associated therewith, and for other purposes incidental thereto'.

The heritage values of any given area are usually assessed in consultation with the Traditional Owners associated with that area. The outcome of surveys may require the submission of an application to the Aboriginal Cultural Materials Committee (ACMC) under Section 18 of the *AH Act*. The ACMC determines whether disturbance of a site is permissible, but no approvals can be issued until the outcome of any related process under Part IV of the *EP Act* is known.

2.8 MINES SAFETY AND INSPECTION ACT 1994 AND RADIATION SAFETY ACT 1975

The main piece of legislation relating to radiation safety in mineral sands mines in Western Australia is Part 16 of the *Mines Safety and Inspections Regulations 1995* (*MSIR*) under the *Mines Safety and Inspections Act 1994* administered by DMP. Key requirements of Part 16 of the *MSIR* include:

- Conducting baseline radiation monitoring prior to the development of a mine.
- Submission of a Radiation Management Plan (RMP) for the approval of the State Mining Engineer.
- Appointment of a radiation safety officer.
- Designation of controlled and supervised areas.
- Application of dose limits.
- Reporting of incidents.

Further legislation relating to radiation safety in Western Australia is stipulated the *Radiation Safety Act 1975* and *Radiation Safety (General) Regulations 1983* administered by the Radiological Council; an independent statutory body appointed under the Act to provide advice to the Minister of Health. The regulations apply to issues such as exemption levels of radioactive materials, the registration of premises and licensing of persons to conduct practises with radioactive materials, radiation monitoring, record keeping, storage, and accounting for radioactive material.

In Western Australia, exposure to ionising radiation and the handling of radioactive materials in mineral sands mining operations is co-regulated by both DMP and the Radiological Council. The co-regulation is enabled by the RMP as both government agencies are required to approve the RMP for the mining operation. The DMP is the lead regulator for the operation of Mine Sites.

Sheffield will prepare and implement a RMP for the project.

2.9 SECONDARY APPROVALS

Secondary approvals likely to be required for the project are summarised in Table 4.

Table 4: Summary of Secondary Approval Requirements

Agency	Legislation	Approval Required
Department of Mines and Petroleum	*Mining Act 1978*	Grant of Mining Lease and Miscellaneous Licences
	Mines Safety and Inspection Act 1994	Project Management Plan Radiation Management Plan
	Dangerous Goods Safety Act 2004	Dangerous Goods Licence
Department of Environment	*Environmental Protection Act 1986*	Works Approval Environmental Licence
Shire of Derby West Kimberley	*Planning and Development Act 2005* *Health Act 1911*	Planning consent and building applications Derby Wharf Sub-Lease (agreement) Waste Water Treatment Plant Approval
Department of Health	*Health Act 1911* *Health (Treatment of Sewage and Disposal of Effluent and Liquid Waste) Regulations 1974*	Waste Water Treatment Plant Approval
Department of Water	*Rights in Water and Irrigation Act 1911*	Licence to take Groundwater Permit to Construct or alter a well (Section 26D)
Radiological Council	*Radiation Safety Act 1975*	Radiation Management Plan
Main Roads Western Australia	*Main Roads Act 1930*	Access Road/Great Northern Highway intersection
Department of Parks and Wildlife	*Wildlife Conservation Act 1950*	Fauna handling licence
Department of Aboriginal Affairs	*Aboriginal Heritage Act 1972*	Section 18 Approval (to interfere with Aboriginal heritage site)
National Native Title Tribunal	*Native Title Act 1993 (Cth)* *Native Title (State Provisions) Act 1999*	Section 31 Deed

2.10 OTHER RELEVANT LEGISLATION

There are a range of other acts and regulations that are likely to apply to the project, some of which require secondary approvals to be obtained as part of project development. Other legislation relevant to the project is listed below:

- *Biosecurity and Agricultural Management Act 2007.*
- *Conservation and Land Management Act 1984.*
- *Contaminated Sites Act 2003.*
- *Dangerous Goods Safety Act 2004.*

- *Dangerous Goods (Transport) Act 1998.*
- *Environmental Protection (Noise) Regulations (1997).*
- *Environmental Protection (Rural Landfill) Regulations (2002*).
- *Explosives and Dangerous Goods Act 1961.*
- *Local Government Act 1960.*
- *Mines Safety and Inspection Act 1994.*
- *Mines Safety and Inspection Regulations 1995*.
- National Environmental Protection (Ambient Air Quality) Measure (2003).
- *Soil and Land Conservation Act 1976.*
- *Wildlife Conservation Act 1950.*

2.11 RELEVANT POLICIES AND GUIDELINES

There are many Commonwealth and Western Australian Policies and Guidelines which are relevant to the project and will be used to in the assessment of this project. These include (but are not limited to) those listed in Table 5. There are numerous other guidance materials such as codes of practice, technical notes, and position statements that accompany these guidelines but are not expressly referred to in this PER and are not listed in Table 5.

Table 5: Relevant Commonwealth and Western Australian Policies and Guidelines

Owner	Policy/Guideline	Date
Commonwealth		
ANZECC & ARMCANZ	Australian and New Zealand Guidelines for Fresh and Marine Water Quality.	2000
ARPANSA	Code of Practice and Safety Guide for Radiation Protection and Radioactive Waste Management in Mining and Mineral Processing.	2005
	Code of Practice for the Safe Transport of Radioactive Material.	2008
DoEE	Threat Abatement Plan for the Impacts of Marine Debris on Vertebrate Marine Life. DEWHA.	2009
	Survey Guidelines for Australia's Threatened Mammals: Guidelines for detecting mammals listed as threatened under the *Environment Protection and Biodiversity Conservation Act 1999*. DSEWPC.	2011
	Environment Protection and Biodiversity Conservation Act 1999 Environmental Offsets Policy. DSEWPC.	2012a
	Marine Bioregional Plan for the North-West Marine Region. DSEWPC.	2012b
	Sawfish and River Sharks Multispecies Recovery Plan. DoE.	2015
	How to Use the Offsets Assessment Guide: http://www.environment.gov.au/system/files/resources/12630bb4-2c10-4c8e-815f-2d7862bf87e7/files/offsets-how-use.pdf	2016 online
	Offset Calculation Excel spreadsheet with embedded formulae: http://www.environment.gov.au/epbc/publications/environmental-offsets-policy.html.	2016 online
NWC	Australian Groundwater Modelling Guidelines. Waterlines Report Series No. 82.	2012
TSSC	Approved Commonwealth Conservation Advice on *Pristis zijsron* (Green sawfish).	2008
	Approved Commonwealth Conservation Advice on *Pristis clavata* (Dwarf sawfish).	2009
	Approved Conservation Advice for *Glyphis garricki* (Northern river shark).	2014a
	Approved Commonwealth Conservation Advice on *Pristis pristis* (Largetooth sawfish).	2014b
	Approved Conservation Advice for *Megaptera novaeangliae* (Humpback whale).	2015

Owner	Policy/Guideline	Date
Western Australia		
DAA & DPC	Aboriginal Heritage Due Diligence Guidelines, Version 3.0.	2013
DEC	Air Quality and Air Pollution Modelling Guidance Notes.	2006
	A Guideline for Managing the Impacts of Dust and Associated Contaminants from Land Development Sites, Remediation and Other Related Activities.	2011
DER	Assessment and Management of Contaminated Sites: Contaminated Sites Guidelines.	2014
DMP	Code of Practice: Tailings Storage Facilities in Western Australia.	2013
	Guide to the Preparation of a Design Report for Tailings Storage Facilities (TSFs).	2015
	Guideline for Mining Proposals in Western Australia.	2016a
DMP & EPA	Guidelines for Preparing Mine Closure Plans.	2015
DoH	Health Impact Assessment in WA. Summary Document.	2007a
	Health Impact Assessment in WA. Discussion Paper.	2007b
DoW	State Water Quality Management Strategy Document No. 6: Implementation Framework for Western Australia for the Australian and New Zealand Guidelines for Fresh and Marine Water Quality and Water Quality Monitoring and Reporting.	2004
	Operational Policy no. 5.12 - Hydrogeological Reporting Associated with a Groundwater Well Licence.	2009
	Western Australia Water in Mining Guideline. Water licensing delivery report series. Report no. 12.	2013
EPA	**EPA Position Statements**	
	Environmental Protection of Native Vegetation in Western Australia. Position Statement No. 2.	2000
	Terrestrial Biological Surveys as an Element of Biodiversity Protection. EPA Position Statement No. 3.	2002
	Environmental Protection of Wetlands. Position Statement No. 4.	2004a
	EPA Guidance for the Assessment of Environmental Factors	
	Implementing Best Practice in Proposals Submitted to the Environmental Impact Assessment Process. Guidance for the Assessment of Environmental Factors No. 55.	2003
	Assessment of Aboriginal Heritage. Guidance for the Assessment of Environmental Factors No. 41.	2004b
	Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia. Guidance for the Assessment of Environmental Factors No. 51.	2004c
	Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia. Guidance for the Assessment of Environmental Factors No. 56.	2004d
	Separation Distance between Industrial and Sensitive Land Uses. Guidance for the Assessment of Environmental Factors No. 3.	2005
	Rehabilitation of Terrestrial Ecosystems. Guidance for the Assessment of Environmental Factors No. 6.	2006a
	Sampling Methods and Survey Considerations for Subterranean Fauna in Western Australia. Guidance for the Assessment of Environmental Factors No. 54a. Draft.	2007
	Sampling of Short Range Endemic Invertebrate Fauna for Environmental Impact Assessment in Western Australia. Guidance for the Assessment of Environmental Factors No. 20.	2009a
	EPA Environmental Assessment Guidelines	
	Protection of Benthic Primary Producer Habitats in Western Australia's Marine Environment, Environmental Assessment Guideline No. 3.	2009b
	Environmental Assessment Guideline for Marine Dredging Proposals. Environmental Assessment Guideline 7.	2011
	Environmental Assessment Guideline for Consideration of subterranean fauna in environmental impact assessment in Western Australia. Environmental Assessment Guideline 12.	2013a

Owner	Policy/Guideline	Date
	Environmental Assessment Guideline for Consideration of environmental impacts from noise. Environmental Assessment Guideline 13.	2014a
	Environmental Assessment Guideline for Application of a Significance Framework in the Environmental Impact Assessment Process. Environmental Assessment Guideline 9.	2015b
	Environmental Assessment Guideline for Environmental Principles, Factors and Objectives. Environmental Assessment Guideline 8.	2015c
	Environmental Assessment Guideline for Preparation of Management Plans Under Part IV of the *Environmental Protection Act 1986*. Environmental Assessment Guideline 17.	2015d
	Environmental Assessment Guideline for Protecting the Quality of Western Australia's Marine Environment. Environmental Assessment Guideline 15.	2015e
	EPA Environmental Protection Bulletins	
	Protection of Naturally Vegetated Areas Through Planning and Development. Environmental Protection Bulletin No. 20.	2013b
	Environmental Offsets. Environmental Protection Bulletin No. 1.	2014b
	EPA Involvement in Mine Closure. Environmental Protection Bulletin No. 19.	2015f
	Guidance on the EPA Landforms Factor. Environmental Protection Bulletin No. 23.	2015g
	Greenhouse Gas Emissions and Consideration of Projected Climate Change Impacts in the EIA Process. Environmental Protection Bulletin No. 24.	2015h
	EPA - Other	
	WA Environmental Offsets Guidelines.	2014c
	Checklist for documents submitted for Environmental Impact Assessment on marine and terrestrial biodiversity.	online
EPA & DEC	Technical Guide - Terrestrial Vertebrate Fauna Surveys for Environmental Impact Assessment.	2010
EPA & DPaW	Technical Guide – Flora and Vegetation Surveys for Environmental Impact Assessment.	2015
WA Government	WA Environmental Offsets Policy.	2011
WAPC	Road and Rail Transport Noise and Freight Considerations in Landuse Planning. State Planning Policy 5.4.	2009

Key: *ANZECC – Australia New Zealand Environment and Conservation Council.*
ARMCANZ – Agriculture and Resource Management Council of Australia and New Zealand
ARPANSA – Australian Radiation Protection and Nuclear Safety Agency.
DAA – Department of Aboriginal Affairs.
DEC – Department of Environment and Conservation.
DER – Department of Environment Regulation.
DoE – Department of the Environment.
DoEE – Department of the Environment and Energy.
DoH – Department of Health.
DMP – Department of Mines and Petroleum
DPaW – Department of Parks and Wildlife
DPC – Department of Premier and Cabinet.
DSEWPAC – Department of Sustainability, Environment, Water, Population, and Communities
EPA – Environmental Protection Authority
NWC – National Water Commission.
TSSC - Threatened Species Scientific Committee.
WAPC – Western Australian Planning Commission.

3. PROJECT DESCRIPTION

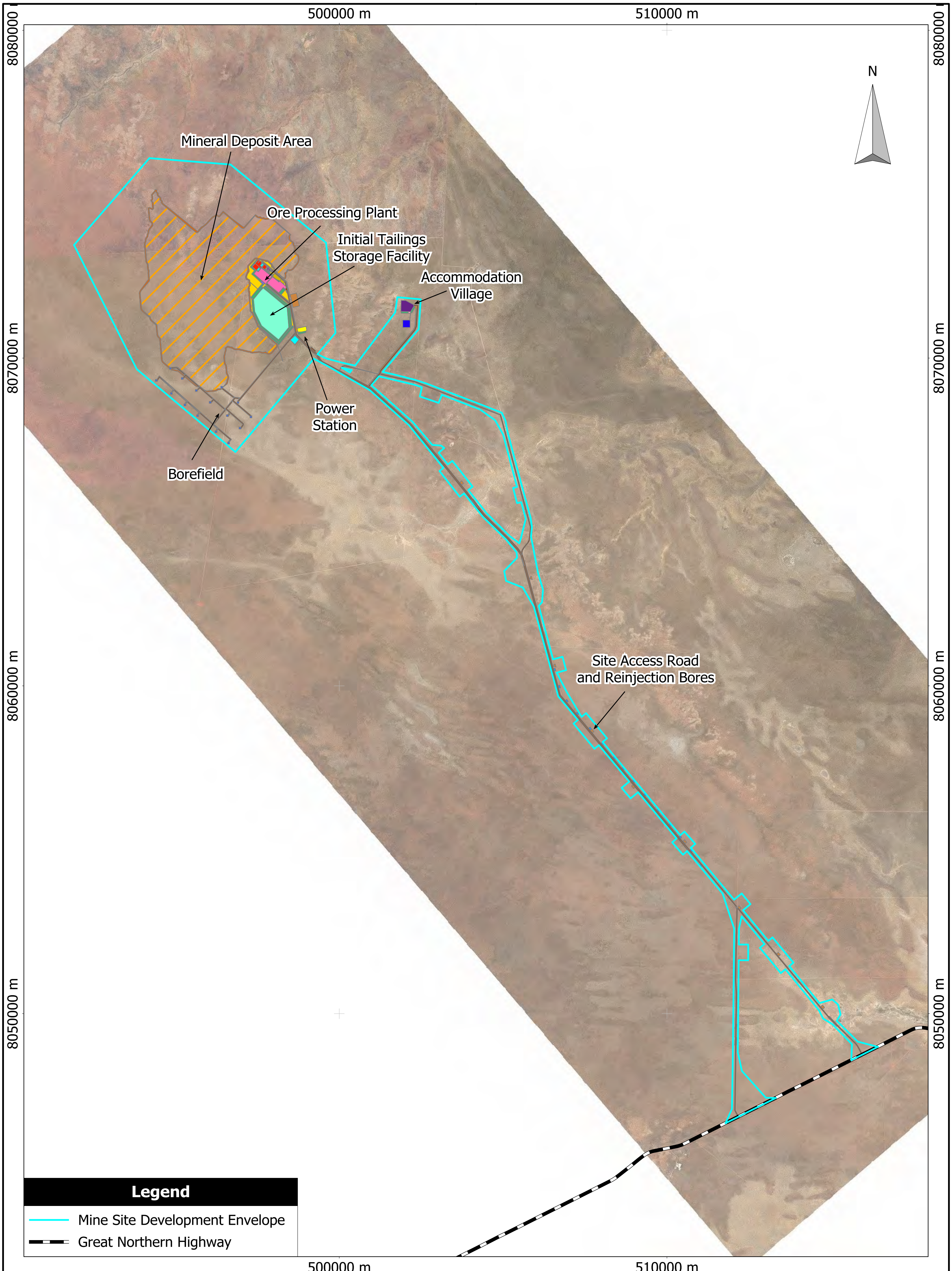
3.1 KEY CHARACTERISTICS

The key characteristics of the Thunderbird Mineral Sands Project are provided in Table 6.

Table 6: Key Characteristics of the Project

Summary of the Proposal		
Proposal Title	Thunderbird Mineral Sands Project	
Proponent Name	Sheffield Resources Limited	
Short Description	The project is located approximately 95 km northeast of Broome and 75 km west of Derby in Western Australia. The project includes heavy mineral sands mining above and below the water table, dewatering within the Broome Sandstone Aquifer, onsite mineral processing, transport of bulk mineral sands products to Derby Port and transhipping bulk product via King Sound using new and existing infrastructure at Derby Port and transport of packaged products to the Port of Broome for export using existing infrastructure. The project includes: • Mining up to a depth of approximately 100 m below ground level. • Processing of heavy mineral sands including use of a tailings storage facility. • Progressive backfilling of the mine pit and rehabilitation of backfilled areas. • Upgrade and extension of an existing road, and construction of a new road, to provide an approximately 30 km long Site Access Road linking the project to the Great Northern Highway. • Groundwater abstraction from the Broome Sandstone Aquifer. • Supporting infrastructure including internal roadways, accommodation camp, power plant, workshops, offices and landfill. • Storage and export of bulk mineral sands products from Derby Port and export of packaged products from the Port of Broome.	
Physical Aspects		
Aspect	**Location**	**Proposed Extent Authorised**
Mine Site Development Envelope		
Mining excavation	Figure 6	Progressive clearing and mining of no more than 1,635 ha within a 5,875 ha Development Envelope over a 40+ year timeframe. Approximately 200 ha of mine pit open at any one time, with progressive backfilling and rehabilitation.
Processing Infrastructure	Figure 12	Clearing of no more than 40 ha within a 5,875 ha Development Envelope.
Borefield	Figure 4	Clearing of no more than 15 ha within a 5,875 ha Development Envelope.
Tailing Storage Facility	Figure 4	Clearing of no more than 110 ha within a 5,875 ha Development Envelope.
Other Supporting Infrastructure	Figure 4	Clearing of no more than 320 ha within a 5,875 ha Development Envelope.
Site Access Road	Figure 4	Clearing of no more than 160 ha within a 5,875 ha Development Envelope.

Derby Port Development Envelope		
Storage/export Facility	Figure 15	Construction of port storage/export facility on existing disturbed port land.
Operational Aspects		
Element	**Location**	**Proposed Extent**
Mineral Sands Processing	Figure 12	• 0 – 5 years: initial tailings deposition in tailings storage facility at 7.5 Mtpa. • 1 year - 5 years: tailings deposition in mine pit at 7.5 Mtpa. • 5 years - life of mine: waste and tailings backfilled to mine pit at 15 Mtpa.
Water Supply Requirements	Figure 4	Borefield abstraction up to 13 GL per annum for Mine Site use during commissioning. Mine Dewatering abstraction up to 33 GL per annum once mining below the water table commences. Groundwater reinjection up to approximately 22 GL per annum once mining below the water table commences.
Power	Figure 4	35 MW multifuel (gas and/or diesel) power plant.
Transport, Storage at Port and Shipping of Product	Figure 14 Figure 16	• Bulk product transport by road train to Derby Port via Site Access Road and Great Northern Highway (approximately 145 km total). • Storage of up to 50,000 t of mineral sands products in an enclosed facility at Derby Port. • Transhipment of bulk mineral sands products via barges from Derby Port to ships anchored at existing sea transfer point at Point Torment. Possibility of using other commercial export options currently under consideration by third parties including use of a lock system. • 20 – 40 sailings/annum from Derby Port depending on ship size. • Storage of up to 10,000 t of packaged products at the Port of Broome. • 20 – 30 sailings/annum from the Port of Broome depending on customer orders.



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Sheffield Resources Limited
Thunderbird Mineral Sands Project

Figure 4

Mine Site Development Envelope Infrastructure Layout

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W:\Sheffield Resources\PER\Drawings\PER Map.map 11/11/2016 F04 Minesite Development Envelope A4P

3.2 TIMING AND STAGING OF PROJECT

The project will have a life of mine more than 40 years excluding construction. It will be constructed and operated in two stages:

- **Stage 1:** Single Mining Unit Plant (MUP) and processing facility targeting mining and treatment of around 7.5 Mtpa of ore from years 0 to 5.
- **Stage 2:** Two MUPs and additional processing capacity targeting mining and treatment of around 15 Mtpa of ore for the remainder of life of mine.

Stage 2 will commence approximately 4 years after Stage 1, however full production (15 Mtpa) will not occur until around year 5. Total material movements will vary over the mine life to enable a consistent ore stream matching the above treatment rates.

Commencement of construction for Stage 1 of the project is anticipated in 2017. Following commissioning, the project is expected to operate continuously throughout the mine life. Initially all mining will be above water table, with consistent mining below water table necessary in the later stages of mining (i.e. after Year 15) in areas where the orebody is deeper.

3.3 MINING OPERATIONS

3.3.1 Mining Method

The mining sequence is typical of mineral sand mining in Western Australia, and dry mining techniques (i.e. no dredging) will be implemented in the mineral deposit area:

- Vegetation and topsoil will be removed and stored (off mine path) or placed directly onto rehabilitation areas.
- Overburden will be removed and either:
  - Stored adjacent to mineral deposit area for later backfilling.
  - Transported directly to (completed) mine areas to be backfilled.
  - Used in the construction of in-pit retaining walls.
- Ore will be excavated and transported to a MUP located on the mining excavation floor close to the active mine face. Two MUPS are anticipated to enable sufficient ore to be delivered to the processing facility.
- The MUP will screen out coarse material to be returned to the mine excavation floor, or crushed/track-rolled and used for ongoing site infrastructure purposes such as road building and pad construction. The screened ore will be pumped as a slurry to a Wet Concentrator Plant (WCP).
- The WCP will further separate particles based on their differential size and density using screens, hydrocyclones and spirals.
- Waste clay and sand, excluding the heavy mineral component will be recombined and returned as co-disposed tailings to form backfill in the mineral deposit area. Flocculant will be added as part of the co-disposal process to enable as much water as possible to be recycled and reused in the WCP. This is achieved by using dewatering cyclones before the damp co-disposed tailings are stacked to form backfill into the mined areas.
- Overburden will be replaced as required to meet landform design and used for tailings cell walls.
- Topsoil will be replaced on contoured areas with scrapers for rehabilitation to the required land use.

Mining will occur within a continually moving area of approximately 200 hectares. Similar to other mineral sands operations, it is anticipated mining, primary backfilling and stabilisation can occur within 3-5 years.

The period between mining and completion of backfill to create the new landform will change depending on the thickness of overburden, ore and final excavation depth. Final rehabilitation earthworks (smoothing, topsoil placement, ripping and seeding) are seasonally dependent and will be completed as soon as practicable after landforms are shaped.

The orebody dips to the southwest; hence there is less overburden in the northeast of the deposit (ore to surface in some areas). At the commencement of operations, there will be insufficient space for simultaneous backfilling of waste, placement of overburden and direct return of topsoil. A tailings storage facility (TSF) will be constructed to contain the initial tailings streams. The TSF will be retained and used as a landform for rehabilitation, providing an opportunity to refine rehabilitation procedures on co-disposed tailings. Once the mining area is large enough, standard mining operations and backfilling as described above will be undertaken.

The mining process is shown schematically in Figure 5. The orebody is not linear; hence the mine path will meander rather than progressing continually in a single direction.

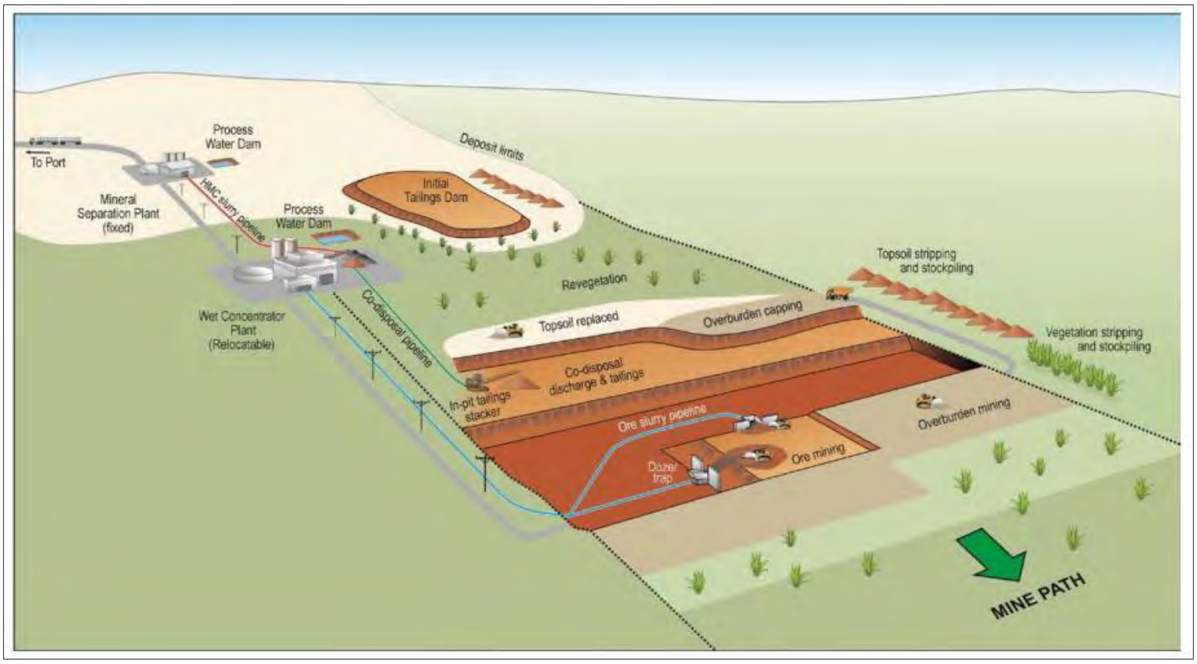
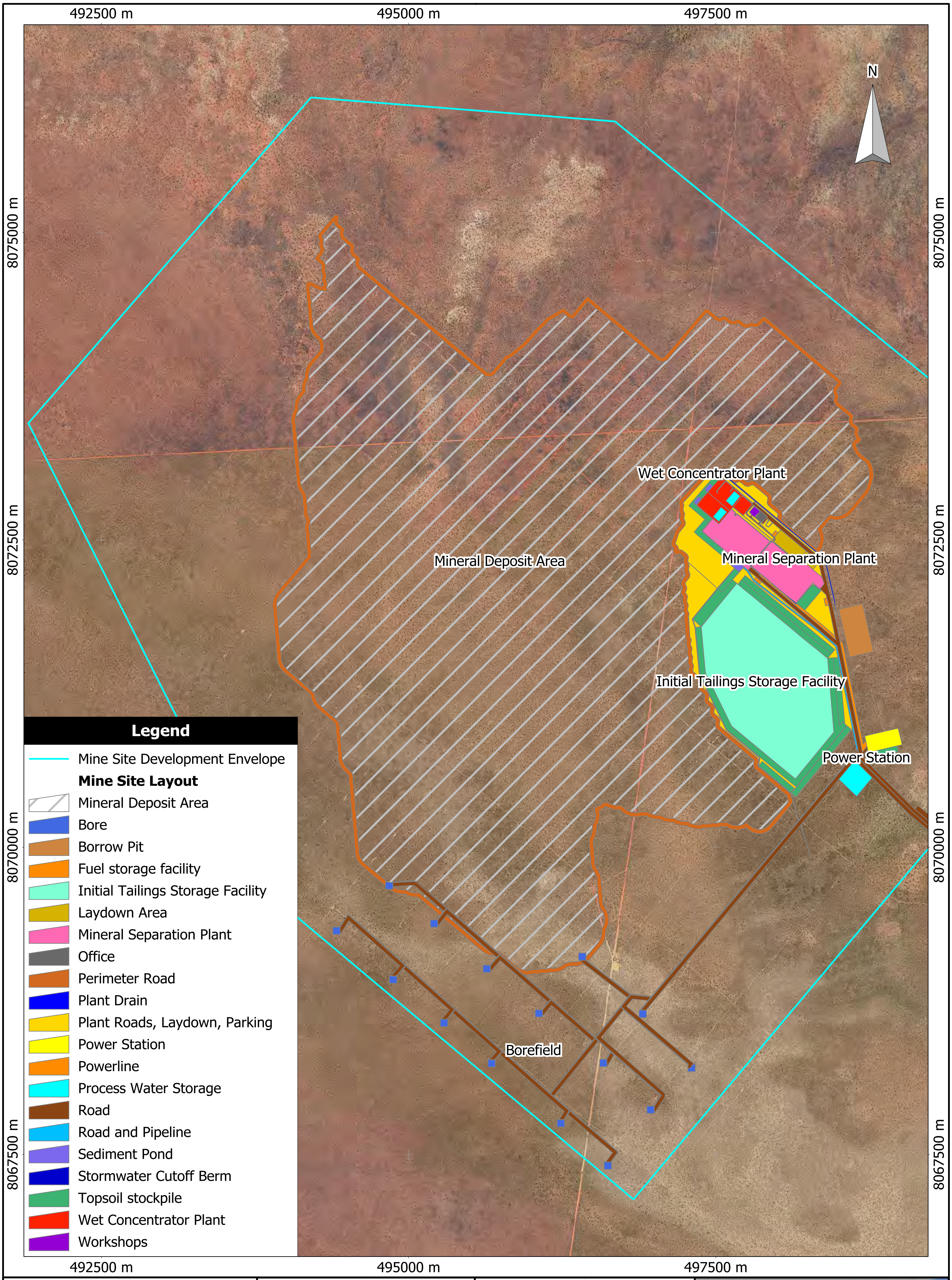


Figure 5: Conceptual Mining Method Schematic

3.3.2 Mine Design

The Thunderbird deposit has a reserve of 31.2 million tonnes of heavy mineral, in an orebody of about 683 million tonnes of predominantly quartz sand. The orebody occurs within a thick, broad anticlinal (arch-like fold) sheet with the top of mineralisation occurring at the surface in the north eastern section of the deposit area and dipping towards the southwest. As a result, pit depth will be 10-12 m at the north eastern end of the deposit, with depth increasing as the ore body dips at a low angle of about 4 degrees to a maximum of approximately 100 m at the southwestern end of the deposit. Figure 6 shows the indicative Life of Mine deposit area footprint and layout within the proposed Mine Site Development Envelope.

The majority of the Thunderbird deposit occurs above the water table. Dewatering of the mine area will need to occur to allow dry mining of the portion below the water table. Pit dewatering will be required from approximately Year 15 initially enabling water from the pit to replace water abstracted from the borefield for use in the processing plants. Eventually as the orebody is mined further below the water table, there will be a positive water balance (more water being pumped from the pit than can be used in processing) so that a portion of the extracted water will be re-injected into the Broome Sandstone Aquifer downstream of mining operations. Therefore, whilst total water abstraction will increase during this phase of mining, net water use will not significantly change.



Scale: 1:40000 Original Size: A4 Air Photo Date: 2015 Grid: Australia MGA94 (51) 0 1 km	Sheffield Resources Limited Thunderbird Mineral Sands Project	**Figure 6** **Proposed Life of Mine Mineral Deposit Footprint and Layout**	Martinick Bosch Sell Pty Ltd 4 Cook St West Perth WA 6005 Ph: (08) 9226 3166 Fax: (08) 9226 3177 info@mbsenvironmental.com.au www.mbsenvironmental.com.au MBS ENVIRONMENTAL

W:\Sheffield Resources\PER\Drawings\PER Map.map 11/11/2016 F06 Proposed Life of Mine Mineral Deposit Area A4P

When mining above the water table, drainage sumps will be located in the floor of the pit to recover in-pit seepage and runoff water. The recovered water from within the pit will be kept within a closed process water circuit for re-use in mining and processing operations.

Whilst there are no well-defined water courses traversing the mineral deposit area, a series of temporary pit bund walls (expected to be around 2 m in height) will be constructed around the active pit to prevent surface stormwater runoff from entering. Any surface water sheet flow will be directed around the active mining area. Following extreme storm events, water may be pumped within the open mine area to enable the resumption of mining as soon as possible. The drainage controls will be constructed, removed and rehabilitated with final landforms and drainage established as the mine proceeds along path. These features will also ensure no inadvertent access to the active mine area.

The mine design is a standard mineral sands design, with pit wall batters of 35 to 40 degrees, and benches where required. Co-disposal of tailings into the pit void eliminates the need for off-mine path drying dams and subsequent recombination of coarse and fine tailings materials during backfill and is more water efficient. Once sufficient pit area is developed, internal walls will be created to retain the dewatered in-pit tailings stream. Overburden may be placed above or below the tailings to ensure materials balances allow the landform to tie in with existing topography.

The general configuration and sequencing of mining both above and below the water table is indicated in Figure 7 and Figure 8 respectively. Expected quantities of overburden and ore to be mined during the project life are shown in Table 7.

Table 7: Expected Life of Mine Overburden and Ore Quantities (Million tonnes)

Year	Ore Mined	Overburden Removed
1	6.2	0
2 - 5	39.7	1.6
6 - 10	85	3.4
11 - 15	77.5	39
16 - 20	76	36.7
17 - 25	77	46.5
26 - 30	76	54.8
31 - 35	73.4	61.5
36 - 40	73.2	80.3
41 - 45	73.7	97.2
46 - 47	27.9	17.3
Total	**685.60**	**438.30**

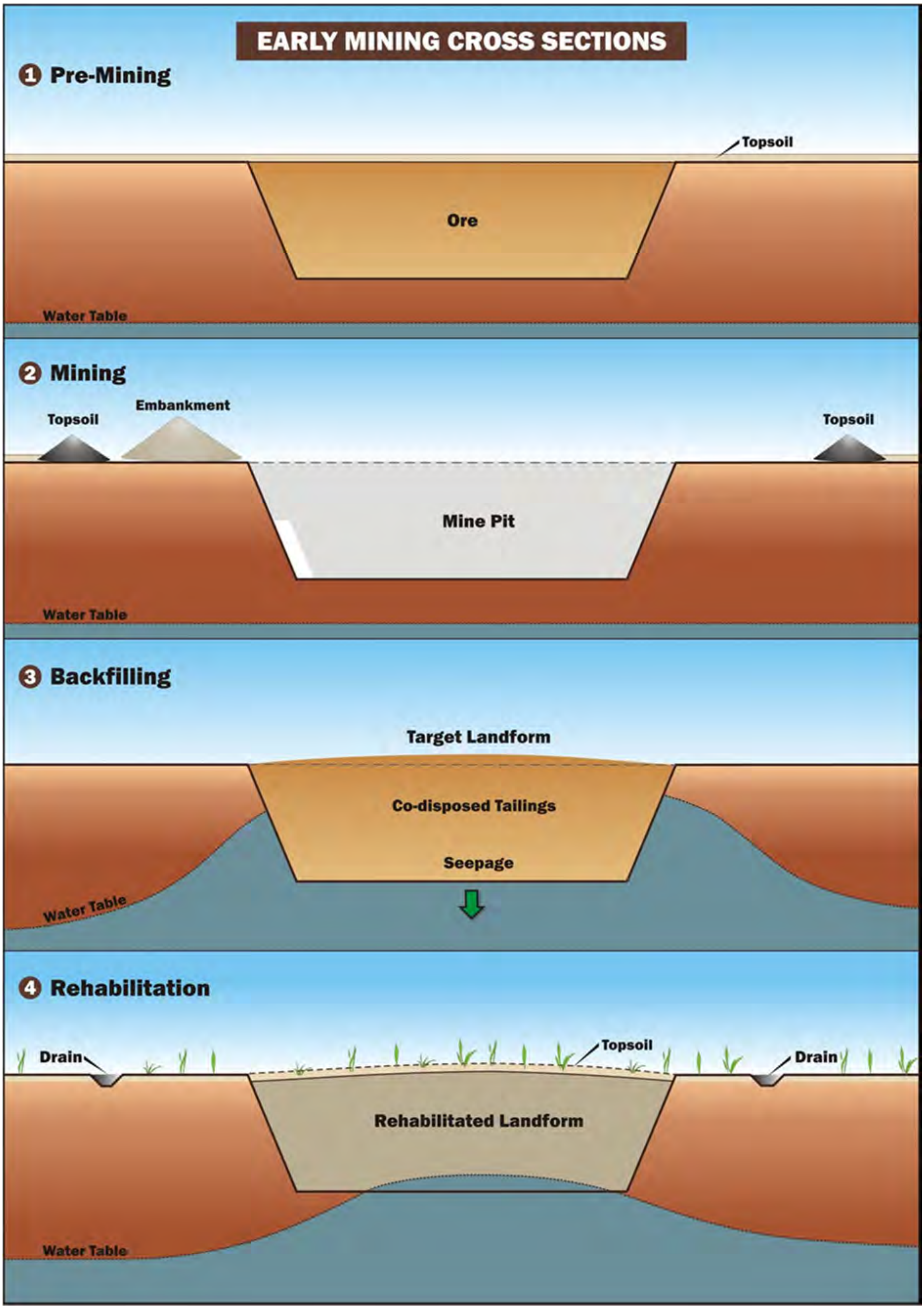


Figure 7: Mine Cross Section – Mining Above Water Table

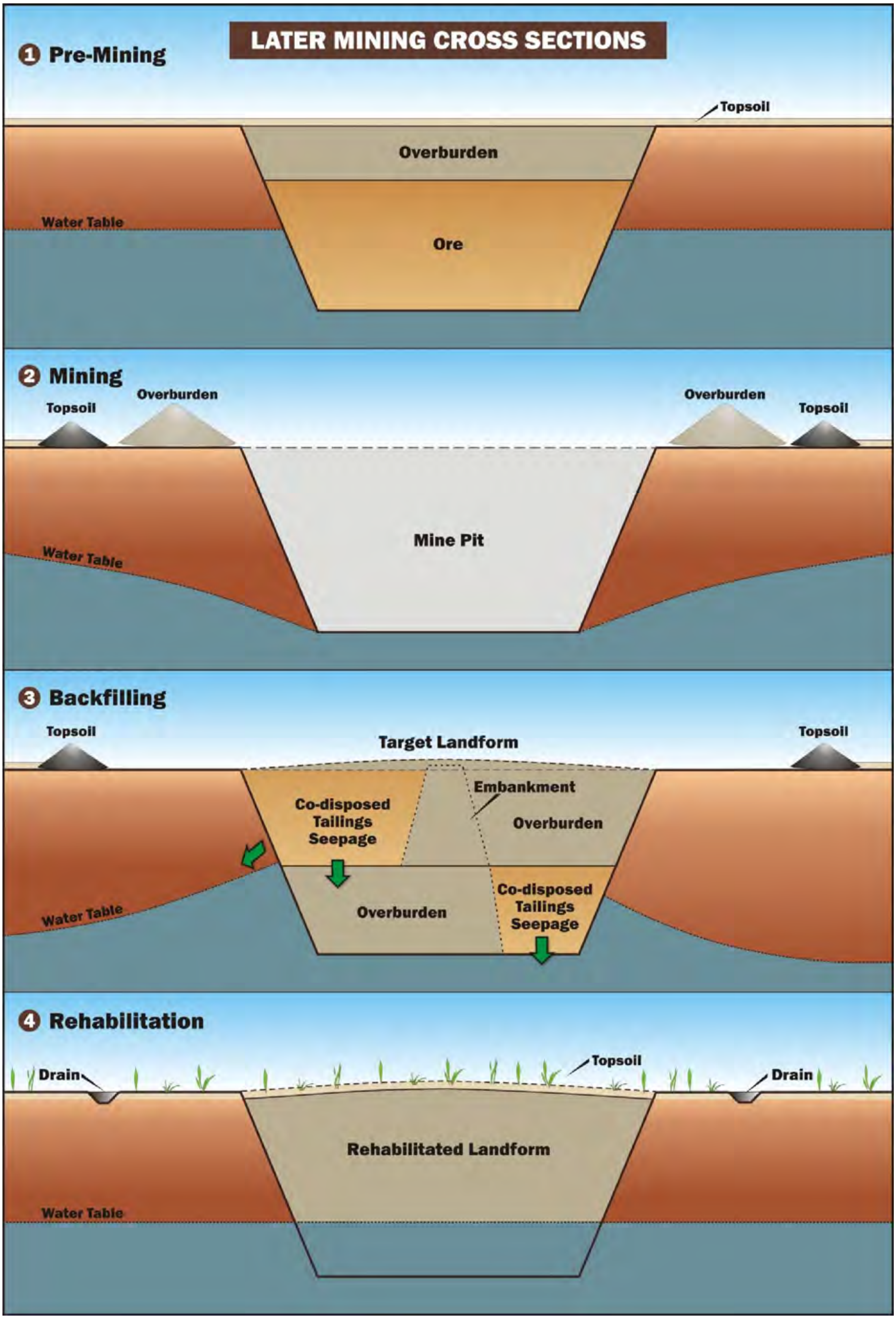


Figure 8: Mine Cross Section – Mining Below Water Table

3.3.3 Mine Schedule

The mining method requires opening up of a mining face within a pit, with systematic backfilling, landforming and rehabilitation behind as shown schematically in Figure 5. Mining will commence in the northern section of the orebody and will progressively expand outwards and generally south westwards. The current indicative mine schedule is shown diagrammatically in Figure 9, indicating the approximate timing for mining of ore.

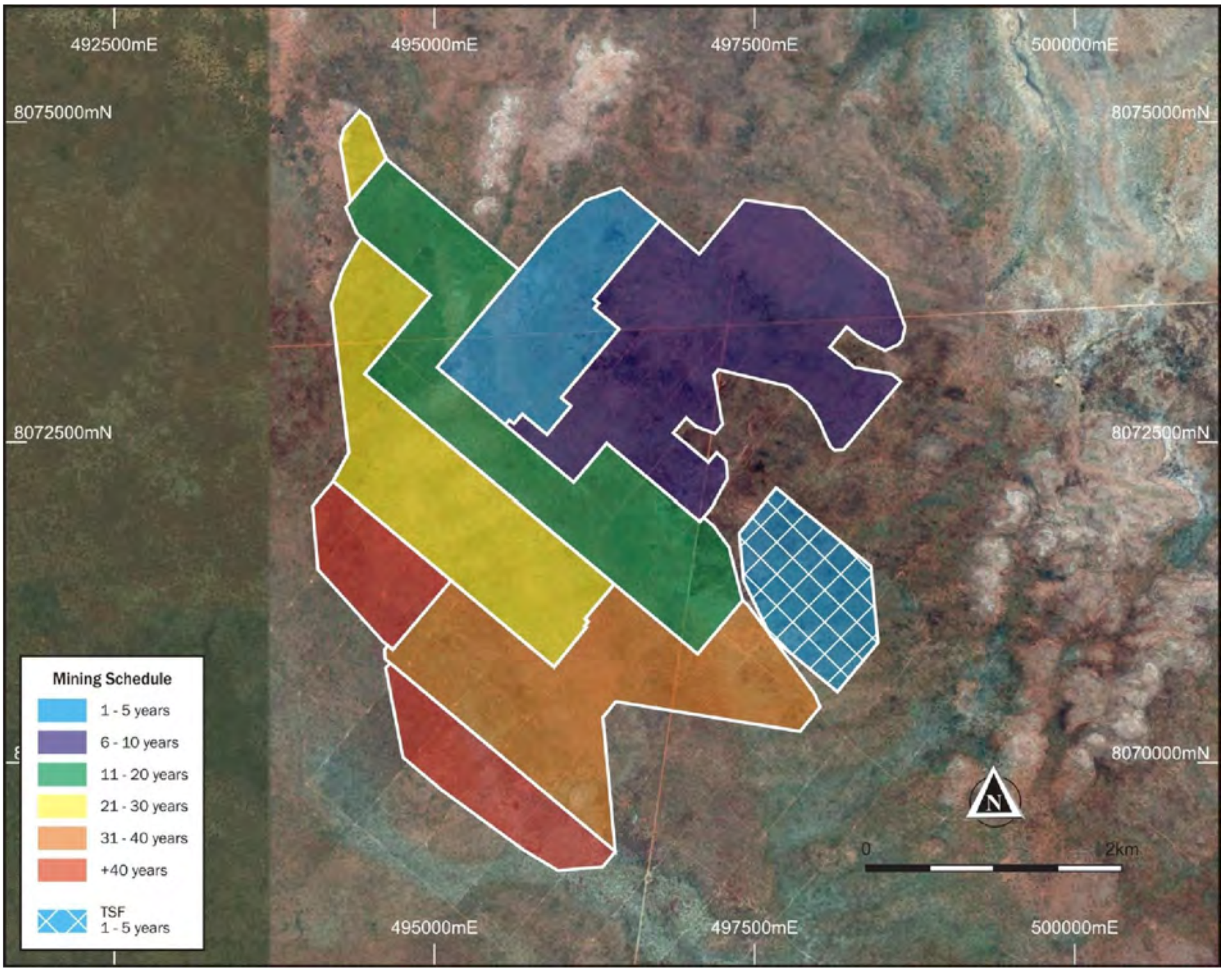


Figure 9: Proposed Mining Schedule

Backfilling will commence as soon as areas become available. Following backfilling and consolidation, it is expected that areas will become available for rehabilitation within five years after mining. Opportunities for direct replacement of topsoil (i.e. stripped from one area and placed directly onto a prepared rehabilitation surface without needing to be stockpiled) will be actively pursued.

Mine schedules are subject to regular revision and will be developed in more detail during operations. The general pattern of mine progression will be driven by economic factors – areas of higher value ore are most attractive to mine early in the schedule.

Expected quantities of overburden and ore to be mined during the project life are shown in Table 7.

Mining and processing will be carried out on a continuous basis - 24 hours per day, 7 days per week. Maintenance shutdowns may be required from time to time for the processing plant.

3.3.4 Mine Dewatering

Mining requires excavation below the water table in the later part of the mine life (i.e. after Year 15). To dry mine these sections, dewatering of the ore body will be required.

The individual requirements for pit dewatering will vary with location and to a lesser degree with seasons. Dewatering bores will be established ahead of the mine path, with pumping to maintain water levels beneath the pit floor until the area is backfilled. Extracted water will be used to support the processing activities and ancillary water requirements as first preference. When there is excess groundwater extracted, it will be re-injected into the aquifer downstream of the mining operations. The co-disposed tailings will drain as they are placed as backfill, providing an ongoing source of recharge to groundwater levels. The initial TSF will also drain and may result in a small, localised groundwater mound at the beginning of mine life (Section 8.3.2).

Once maximum production levels are attained, the water demand for the processing plant is not likely to vary considerably. As mining progresses deeper, dewatering volumes will exceed the plant water demand. The general timeline for pit dewatering for the mine area is shown in Figure 10 and summarised below:

- **Years 1 to 15:** Groundwater will generally be below the level of the pit floor. Minimal mine dewatering will be required, focusing on collection of seepage from backfilled materials and management of wet season inflows. A water supply borefield will meet water demand at this stage.
- **Year 15 onwards:** Pit floor intersects, or will be below the water table, necessitating dewatering of the active mining area. Dewatering bores will be established ahead of the active mine path, with pumping to maintain water levels beneath the pit floor until the area is backfilled. Dewatering volumes will increase gradually from Year 15 to 32 as mining depths increase and will gradually replace the water supply borefield.
- **Year 32 to Year 47 (approximate):** As for Year 15 – 32, with excess water not able to be used in mining or ore processing operations reinjected into the Broome Sandstone Aquifer.

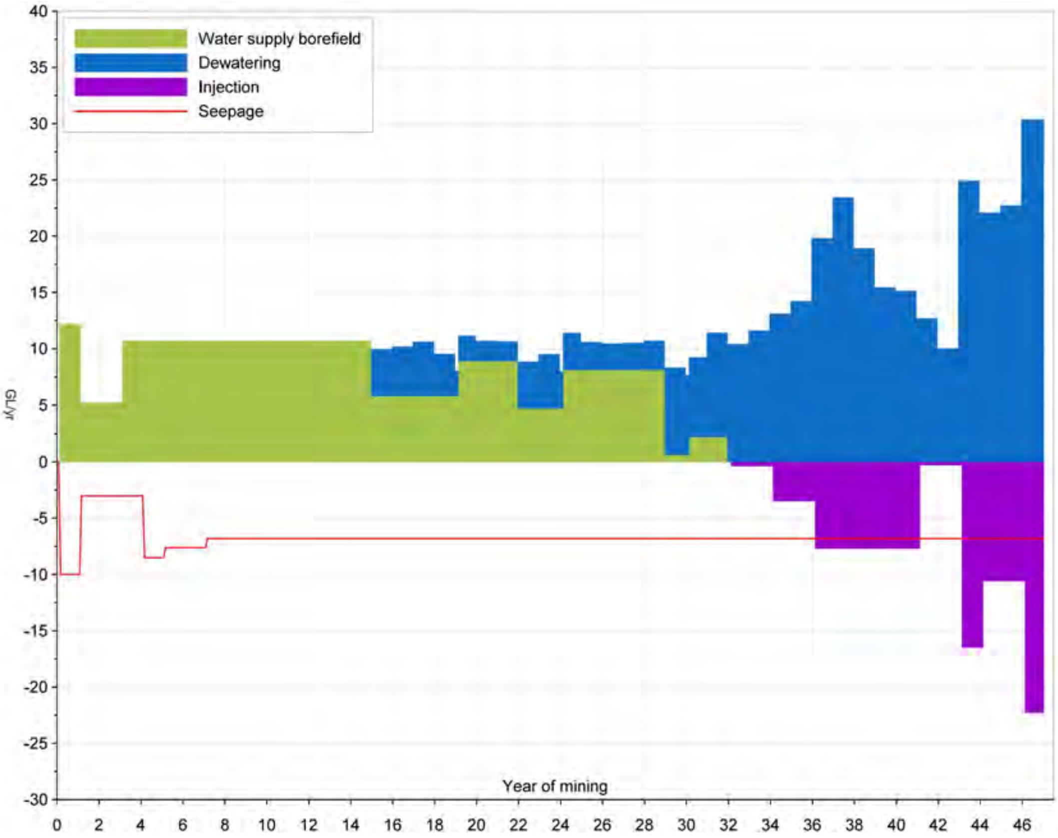


Figure 10: Predicted Life of Mine Water Management Volumes

3.4 ORE PROCESSING

Ore will be processed in a two stage mineral sands processing plant:

- Primary processing in a WCP - The WCP takes the ore in a slurry form and separates particles based on different size and density into "heavy" minerals and non-heavy minerals (clay, sand etc.).
- Secondary processing in a Mineral Separation Plant (MSP) - The MSP takes the output from the WCP (heavy minerals) and uses magnetic and other separation methods in both wet and dry processes to separate the heavy minerals into the final products.

A process flow sheet describing the above is provided in Figure 11. The process is consistent with mineral sands processing at many mine sites in Australia including those near major population centres (e.g. Kwinana, Geraldton, Bunbury). The only reagents used in ore processing comprise acid and caustic soda and lime in the hot acid leach circuit, as well as biodegradable flocculants to aid the settling of fine particles in the tailings thickener and co-disposal stream.

The locations of both the WCP and MSP including the mining services corridor (Figure 12), take into consideration the proximity to the ore body, process water supply and high voltage power reticulation. Ancillary services and infrastructure are located around the processing plant.

Five final products (Ilmenite, Ilmenite LTR450, Primary Zircon, Zircon Concentrate and HiTi88 leucoxene) will be produced for export from the site. A titano-magnetite concentrate produced as by-product of the ilmenite roasting stage may form a sixth saleable concentrate. The products will be stored at the Mine Site in individual product storage bins from which they will be fed to either a bagging plant on a batch or campaign basis as required, or transported and exported as a bulk product.

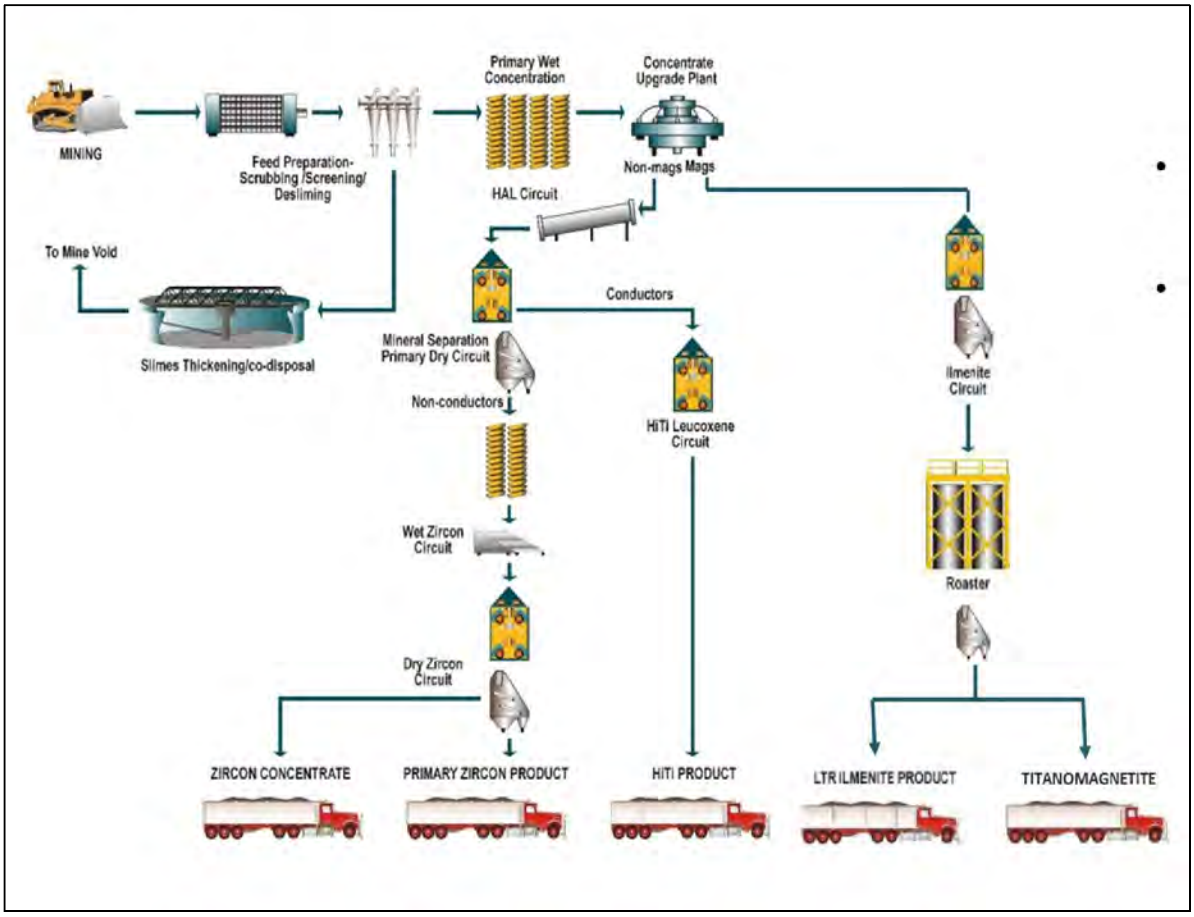
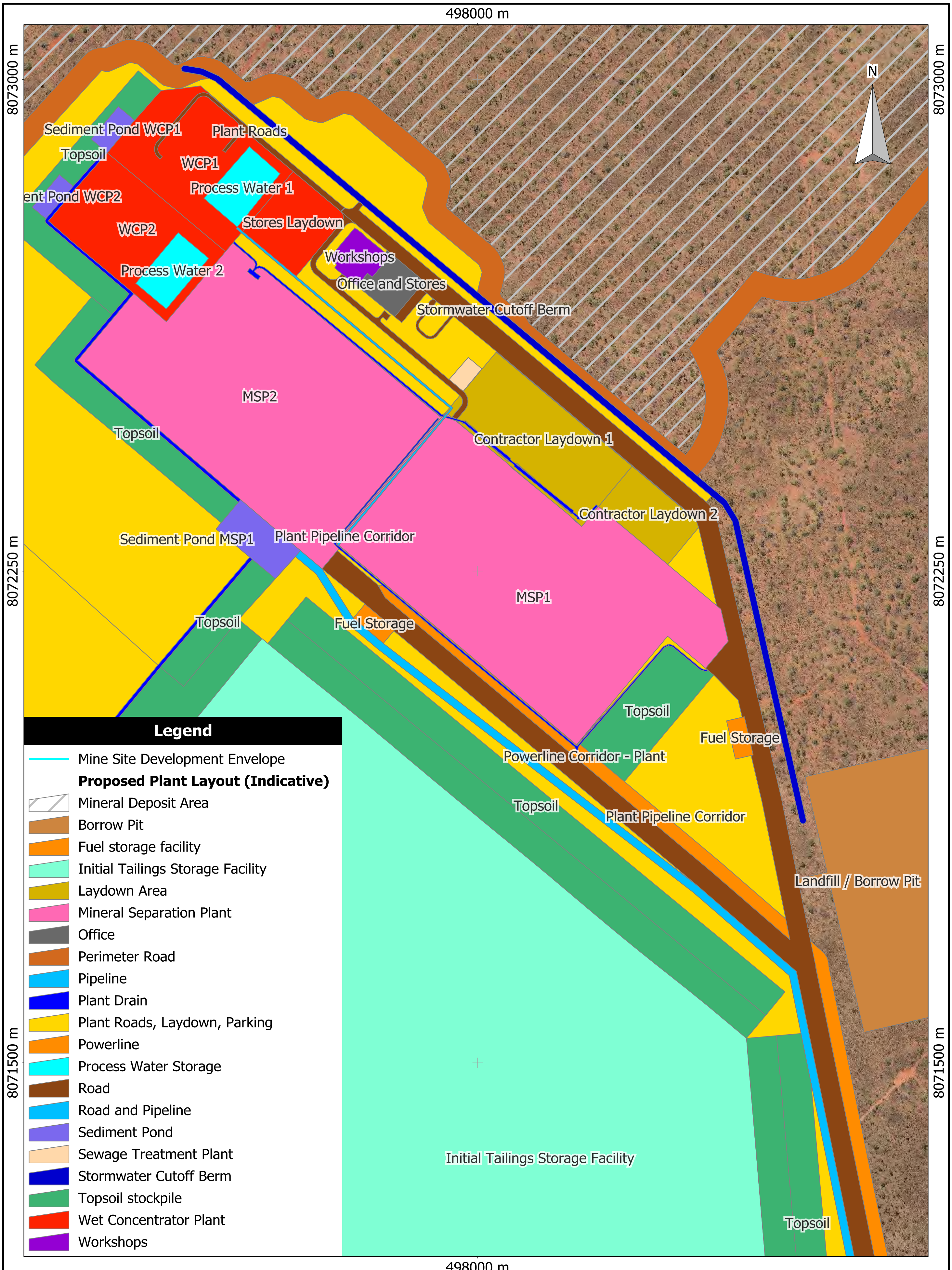


Figure 11: Ore Processing Process Flow Sheet



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Sheffield Resources Limited
Thunderbird Mineral Sands Project

Figure 12

Ore Processing Plant Layout

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3.4.1 Process Waste Types and Volumes

Several different wastes will be produced from the WCP and MSP. The characteristics, disposal plan and proportions are described in Table 8. Apart from gypsum, all residue streams are made up of materials mined from the pit, i.e. they were present in the ground prior to mining.

Table 8: Process Waste Types and Proportions

Residue Stream	Description and Fate	Anticipated % of Processed Material
MUP Oversize (> 5 mm)	Stockpiled for use as roadbase/construction or returned to mine void.	17
MUP Oversize (> 2 mm)	Stockpiled for use as roadbase/construction or returned to mine void.	3
WCP Sand Rejects	Waste non-heavy mineral sand returned to mine void or initial TSF.	50
WCP Tails (slimes)	Initial gravity separation slimes/clay fraction. Returned to mine void or initial TSF.	16
Combined CUP and MSP Tailings	Materials from magnetic separation processes. Returned to mine void or initial TSF.	7
MSP Rejects	Includes zircon plant rejects and ilmenite processing rejects. Returned to mine void or initial TSF.	
Gypsum	Acid neutralisation residue from HAL circuit. Disposed of in gypsum evaporation pond and/or mine void.	0.04
Products exported or stockpiled (Ilmenite, Primary Zircon, Zircon Concentrate, titano-magnetite and HiTi88 Leucoxene)		4
Untreated magnetic stockpile material		2

3.4.2 Process Waste Disposal Methods

Co-disposal is a standard mineral sands tailings management procedure and has been selected for the disposal of the recombined coarse and fine particle streams. The co-disposal stream will combine the WCP and MSP tailings streams with flocculant to rapidly thicken tailings and enable recycling of much of the water used to pump the material to the TSF or mine void. If required, a portion of sand materials can be segregated out and dry stacked to reduce the volume of combined tailings. The sand material may be used for construction purposes within the mining area.

The combined tailings will initially be stored within a TSF until the mining area is prepared for co-disposal of tailings (expected to be in-pit) for the remainder of the project. More details about these waste disposal methods are provided in the following sub-sections.

3.4.2.1 Tailings Storage Facility

During the first few years of operation, all tailings will be pumped as a high density slurry into a purpose-built initial TSF. The initial TSF is required to make sufficient space within the mining void to enable commencement of backfill tailings disposal. The initial TSF will be located on an area of approximately 106 ha, immediately adjacent and to the east of the deposit (Figure 6). The initial TSF will be an unlined paddock-style structure with purpose built embankments. The detailed design will comply with the *Code of Practice for Tailings Storage Facilities in Western Australia* (DMP 2013) and *ANCOLD Guidelines on Tailings Dam Planning, Design, Construction, Operation and Closure* (ANCOLD 2012).

3.4.2.2 Co-disposal within Mining Area

After sufficient space is available within mined areas, tailings are expected to be returned directly to the pit void and stored in a series of internal storage areas formed by bund walls constructed within the pit. The internal bund walls may be constructed from overburden material or consolidated processed materials to provide the necessary stability. The tailings are expected to be initially approximately 40% solids, with entrained water being either recycled back to the process plants, or lost to seepage and evaporation. Recycling of water into the will significantly reduce the demand on make-up water from the borefield.

In-pit tailings disposal is an efficient means of backfilling the mine void and provides for tailings storage over the majority of the life of mine. Following a period of consolidation, overburden and topsoil as required will be placed over the co-disposed tailings where required to bring the landform up to designed post-mine levels. Alternatively, overburden may be direct hauled as backfill into a mine void to avoid stockpiling and double handling. In this case, tailings may be placed over partially filled areas to backfill to design levels. As with other mineral sands operations using fresh processing water, the co-disposed tailings are expected to represent a suitable rehabilitation substrate without the need for overburden cover. The initial TSF provides an opportunity to test this early in the mine life.

3.5 WATER

3.5.1 Water Sources

Water for the project will be supplied from a dedicated borefield and mine dewatering. Up to 50% of the abstracted water will be recycled within the processing circuit as much as possible, although some clean raw water is needed for specific areas within the processing circuit. Water from rainfall and runoff within the mining area may be utilised in the process water circuit to minimise overall water demand. Water will also seep back into the aquifer from tailings waste returned to the mining void. Modelling has shown that this rate will vary a little from year to year, but remain largely consistent.

The anticipated sources of project water (Table 9) and extent of supply required over the life of the project (Table 10) are shown in Figure 10. The overall water demand for the project is met entirely from a borefield in the early years of mine life. This is replaced by water sourced from mine dewatering later in the mine life.

As mine dewatering supply exceeds demand, excess water will be reinjected within the Broome Sandstone Aquifer system at a location downstream of the mine, so that dry mining can occur. Utilising bores, pumps and a pipeline, the reinjection process is contained, meaning that the water is not used or exposed, but transferred and relocated within a closed system. The net water demand of the operation does not change once it reaches its planned production rate.

Table 9: Project Water Supply

<table>
<tr><th colspan="2" rowspan="2">Input</th><th colspan="3">Quantity (GL/yr)</th></tr>
<tr><th>Stage 1
(Year 1 – 3)</th><th>Stage 2
(Year 4 – 15)</th><th>Stage 3
(Year 15+)</th></tr>
<tr><td rowspan="3">Water Abstracted</td><td>Mine dewatering</td><td>0</td><td>0</td><td rowspan="2">10.7 – 32.7</td></tr>
<tr><td>Borefield abstraction</td><td>5.2 – 12.2</td><td>10.7</td></tr>
<tr><td>Total</td><td>5.2 – 12.2</td><td>10.7</td><td>10.7 – 32.7</td></tr>
<tr><td rowspan="2">Water Returned</td><td>Aquifer reinjection</td><td>0</td><td>0</td><td>0 - 22</td></tr>
<tr><td>Modelled seepage</td><td>3.0 - 10.0</td><td>6.8 - 8.5</td><td>6.8</td></tr>
</table>

3.5.2 Water Usage

3.5.2.1 Construction

Up to 120 m^3/h of water will be required over the two year construction schedule at the Mine Site. Construction water will be sourced from groundwater bores; with the three existing test production bores a priority initial source.

3.5.2.2 Operations

Project water requirements during operations are detailed in Table 10. The total water volume required for the project during steady-state operations will be up to 1,219 m^3/h.

Table 10: Project Operation Water Requirements

Demand	Quantity (m^3/h)		
	Year 1	Year 2 and 3	Year 4+
Ore processing	1,252	456	1,082
Accommodation village	25	28	23
General mine use (incl. dust suppression)	114	114	114
Total Water Demand	***1,391***	***598***	***1,219***

3.5.2.3 Groundwater Reinjection

Excess dewatering volumes from about mining Year 32 onwards will be discharged via aquifer reinjection. No other sources of water other than dewatering will be used for aquifer reinjection (for example, stormwater and sewage water will not be directed to the reinjection bores). Up to 15 reinjection bores will be constructed and connected to a water reticulation pipeline (or double pipeline) laid next to the Site Access Road and within the road-clearing corridor. Reinjection bores will be about 50–120 m deep, with screen intervals targeting the Broome Sandstone Aquifer. Pumping head will be provided by submersible bore pumps in the dewatering bores and an intermediate booster pump.

The project area experiences distinct wet and dry seasons (see Section 4.2.2). This may result in significant quantities of water being captured within the active mine area during the wet season, particularly following cyclones. This will be reused where practicable in mining and ore processing activities.

Figure 13 shows a conceptual schematic of water infrastructure required for the project, including the water supply, dewatering and reinjection borefields.

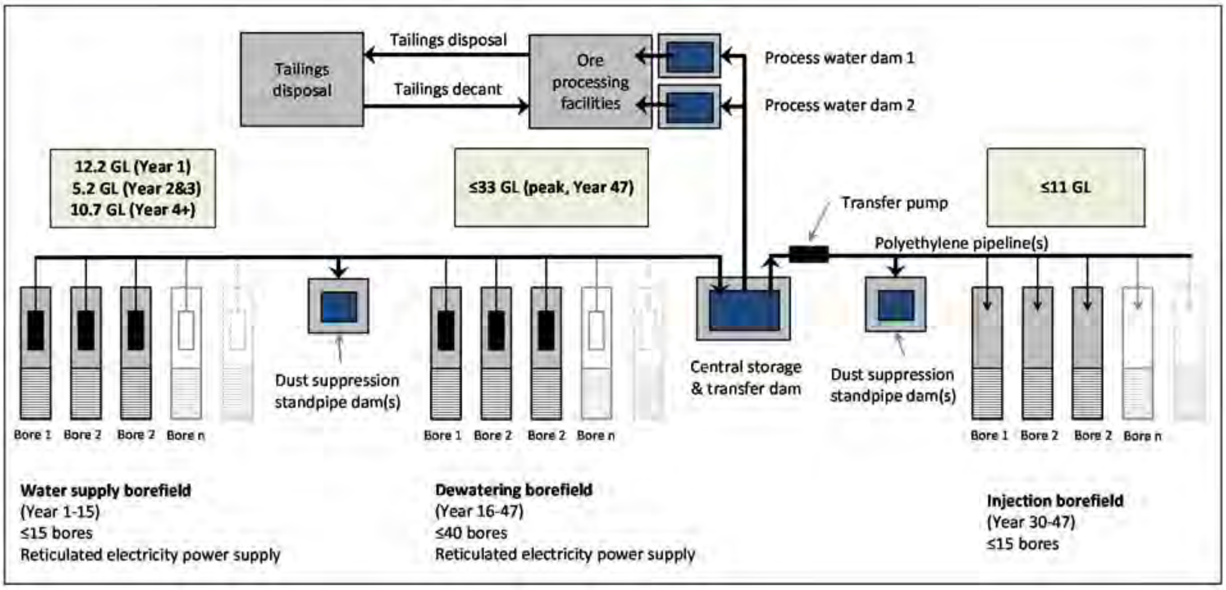


Figure 13: Conceptual Water Infrastructure Schematic

3.5.2.4 Borefield

The water supply and dewatering borefields will operate to achieve the dual aims of providing process water and also dewatering below watertable ore regions from Year 15 onwards. The borefield will initially be situated immediately south of the mining area (Figure 6) and will progressively incorporate near-pit dewatering bores as below watertable regions are included in the mining schedule. Bores will be constructed to about 120 m depth and target the Broome Sandstone Aquifer. For the first 15 years, up to 15 bores will be required to achieve sufficient process water supplies. In peak dewatering years after approximately Year 30, up to 40 bores may be required to maintain dry mining conditions, and additional sump dewatering may be required as a contingency. The dewatering borefield will be linked via an intra-borefield polyethylene pipeline.

The intra-borefield pipeline will transfer water to the ore processing facility and will include water storages (see Table 11) and lie within a pipeline corridor approximately 12 m wide. Polyethylene pipeline will also connect the ore processing facility water storages to the reinjection borefield. The pipeline corridor will be up to 40 km long (including pipeline to the aquifer reinjection bores). The polyethylene pipeline will be up to 650 mm nominal diameter and may include dual pipeline intervals along key sections of the pipeline route. Intermediate pressure-regulation/dust suppression offtake dams will be included in the reinjection pipeline corridor and will include a water standpipe. Other than telemetry control and regular inspections, no further spill protection is required along the pipeline as the water is fresh.

The water supply borefield will be powered by a reticulated electricity power line system that connects the bore control panels to the central power station.

A dedicated bore will provide the accommodation village's potable water supply. The bore will be proximal to the accommodation village and up-gradient of potential contaminant sources (e.g. waste water treatment plant). The bore will be connected to the accommodation village via a polyethylene pipeline of up to 150 mm nominal diameter.

A network of more than 20 local-scale and regional-scale monitoring bores will be established to assess potential groundwater drawdown and mounding impacts.

3.5.2.5 Water Storages

A series of water storages will be constructed within the Mine Site Development Envelope to ensure suitable storages and buffers are maintained for water supply and management. Anticipated water storages are described in Table 11.

Table 11: Mine Site Water Storages

Water Storage Name	Input Source(s)	Purpose
Central storage and transfer dam	Borefield	Regulation of the water management system
Process Water Dam 1 Process Water Dam 2	Borefield	Process plant use
Intermediate pressure-regulation/dust suppression offtake dams	Borefield	Pipeline pressure regulation and/or dust suppression standpipe supply
WCP Dam	Mine void sumps CUP Dam overflow	Process plant use
CUP Thickener Dam	Process plant cyclone overflows Product stockpile seepage collection	Process plant use

3.5.2.6 Surface Water Drains and Diversions

The Mine Site Development Envelope is on sandy soils with low runoff generation, and there are no well-defined watercourses within the mining area. The nearest defined watercourse is the Fraser River South, which develops a visible channel approximately 10.5 km downstream of the deposit and ore processing area, across the Site Access Road.

During extreme rainfall events some surface flows may occur that require surface drainage. The key surface drainage features that may be constructed are:

- TSF Drain – capturing runoff from TSF embankments with water directed to a sump.
- WCP Drain – capturing runoff from WCP areas with water directed to sumps.
- MSP Drain – capturing runoff from MSP areas with water directed to sumps.
- Pit Bund - minimising surface water flow into the active pit, with the location moving as the active mining area changes over time.

3.6 OTHER KEY INFRASTRUCTURE

3.6.1 Power Supply and Distribution

3.6.1.1 Construction

Temporary diesel generators will be used in the construction phase as accommodation facilities are developed, site offices are completed, and bores and water treatment plants are established. Generators purchased for these temporary duties will ultimately be used to provide emergency power, or power at remote locations, once the permanent power station and power distribution network is established and commissioned.

3.6.1.2 Operations

A power plant will be constructed at the Mine Site to provide power for all mining and ore processing activities, and to power associated facilities. The power station will be 35 MW capacity and will utilise generators running on either LNG or diesel/LNG. The power plant will be located southeast of the TSF and will include all necessary fuel facilities for its own supply. Gas and/or diesel will be delivered by truck to the Mine Site and no piping of gas to the project is required.

A reticulated electrical system for the project will be based on 11 kV distribution and 415 V working voltage. Power line corridors will typically follow roads and water pipeline corridors to minimise land disturbance.

3.6.2 Offices and Laboratory

Offices will be established on site during the construction phase. Offices will be located within the processing plant area as well as the mining contractors' compound.

A laboratory will also be established within the processing plant area. On-site laboratories are generally required for production control to maintain grade and refine short-term mine planning. Laboratory testing is also required for process plants to understand ore feed and maintain product quality.

Offices and buildings will be transportable, fabricated off site to withstand wind conditions according to Australian Standard AS 4055-2012.

3.6.3 Fuel Facilities

Storage for up to 600,000 L of diesel (or other) fuel storage may be required for the power station, mining fleet and other vehicles. The power station is expected to be gas-fired, but if this supply arrangement does not eventuate, the contingency is to utilise diesel for fuel and provide storage on site.

The mine fleet will require on-site fuel storage facilities. Two to three 100,000 L fuel storage tanks will be located next to the heavy vehicle workshop which will supply fuel to the heavy and light vehicle mining fleets, anticipated to be sufficient for at least 20 days' operation. The bowser and fuel delivery inlets will be situated on concrete pads to contain any drips and spills.

The road haulage fleet will be supplied with fuel from Derby with no need for refuelling facilities at the mine.

3.6.4 Maintenance Areas and Workshops

A store warehouse and integrated mechanical/electric workshop will be located within the processing area for maintenance activities. A site workshop will be constructed to enable routine maintenance of mine plant and equipment. A yard will be provided adjacent to the workshop for a laydown area of large items.

3.6.5 Wash Down and Waste Oil Facilities

The wash down and waste oil facility will be located adjacent to the mining workshop. Oily wastewater from the wash down facility will accumulate in a sump which is sized to enable periodic removal of waste solids by a loader. Overflow water from the sump will enter a triple interceptor to enable any hydrocarbons to be collected and removed. Waste oil will be stored onsite and periodically removed by a licensed third party contractor.

3.6.6 Accommodation Village

During the construction phase, a temporary construction village will accommodate up to 500 personnel involved in the early construction of the project including the permanent accommodation village, processing plant and access roads. The construction village will be decommissioned and removed once the permanent village is fully operational.

A permanent accommodation village will be constructed to support the long term operation of the project, located approximately 3.5 km from the Mine Site area (Figure 4), and designed to accommodate up to 500 people at peak times such as during planned shut downs and maintenance.

The accommodation village will include ensuite rooms, kitchen/diner, laundries, administration office, tavern, gym, first aid facilities, sporting amenities, verandas, landscaping and services (power, water, sewage, and communications). Due to the projects remoteness, the kitchen diner building will be designed as a cyclone refuge for workers and rated to an importance level 4 building.

3.6.7 Communication Services

Communications services such as telephone and data will be augmented by a communications tower.

3.6.8 Borrow Pits

Borrow material will be required for road construction and other foundations and embankments will be sourced from a combination of nearby commercial quarries, borrow pits and/or construction areas.

3.6.9 Wastewater Treatment Plant

Two waste water treatment plants will be required. One will service the accommodation village and the second will service the Mine Site facilities. Both will comprise package treatment systems with final effluent disposed of by land irrigation.

3.6.10 Solid Waste Management

A Class II landfill site will be constructed in accordance with the *Environmental Protection (Rural Landfill) Regulations 2002* under Prescribed Category 89 for a threshold of ‘More than 20, but less than 5,000 t/a’. Recyclable materials, such as metals, rubber, plastic, paper, glass, and fabric products will be segregated from other wastes and collected from the accommodation village, mine offices, and workshop areas. Hazardous/controlled wastes will be segregated from other wastes and collected mainly from the workshop and processing areas. A bunded and sealed assembly area for containerised hazardous chemicals prior to offsite treatment/disposal will be established.

3.6.11 Bioremediation Facility

A bioremediation pad will be constructed adjacent to the landfill facility. The proposed bioremediation pad will be about 0.25 ha in size (50 m by 50 m). The bioremediation pad will be made up of two cells consisting of one active cell for immediate use and one inactive cell to be used for the process of bioremediation.

3.7 SITE ACCESS AND PRODUCT TRANSPORT

The existing access to the Mine Site is Mt Jowlaenga Road; an unsealed road maintained by the Pastoral Lessee. Parts of the existing road will be upgraded and new sections will be constructed to provide safe, all weather access to the Mine Site. The upgraded Site Access Road will be approximately 30 km long and will meet the minimum requirements of the Main Roads WA standards suitable for Restricted Access Vehicle Category 10 use. The Great Northern Highway intersection with the Site Access Road will allow entry from both Broome and Derby, with overtaking lanes for road trains.

Trucks will be used to deliver construction materials, supplies and remove selected waste streams. Buses and cars will be used for workforce transportation as required. The proximity to Derby and Broome means that no airstrip is required.

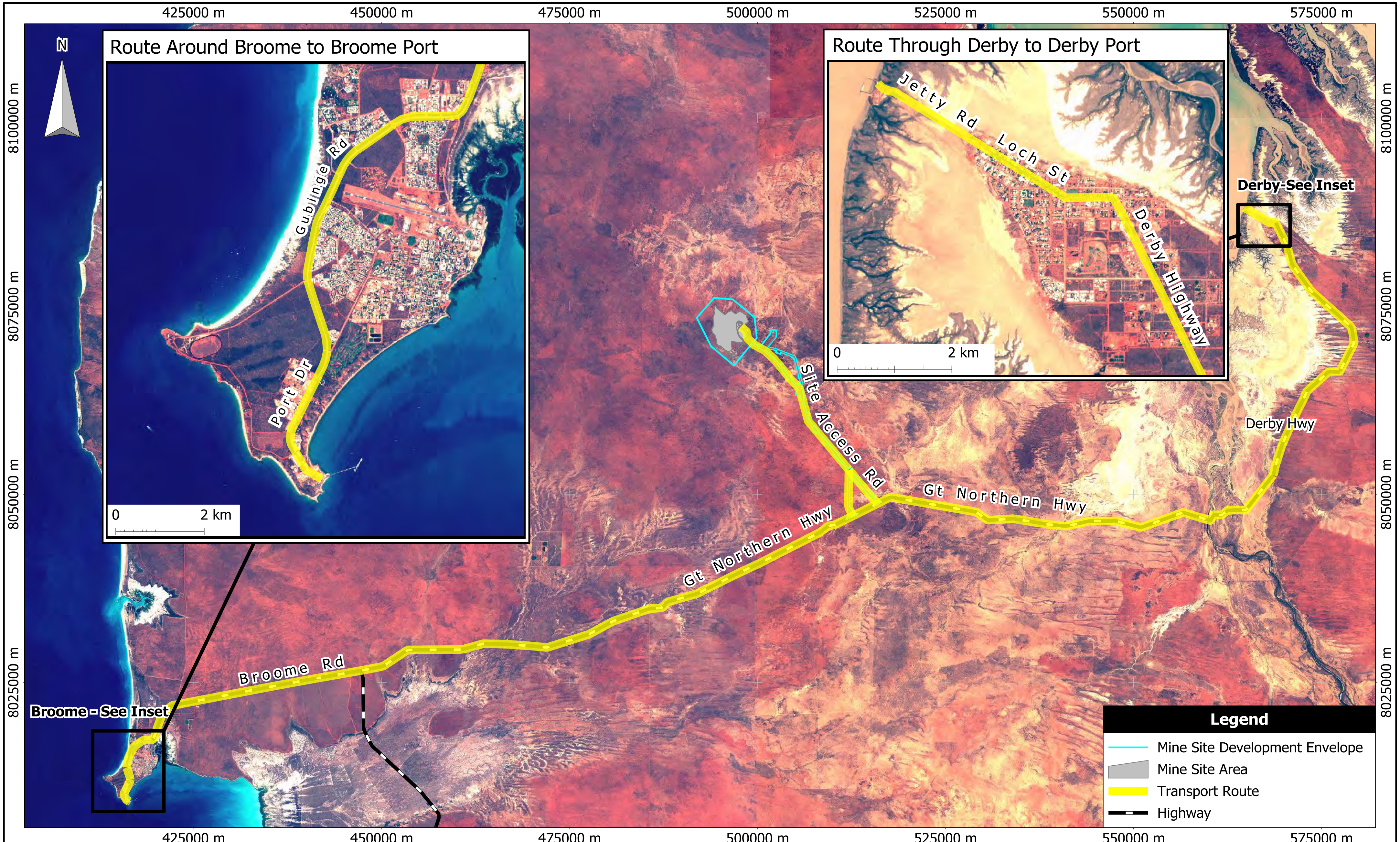
Bulk mineral product from the Mine Site will be loaded on to road trains and transported to Derby Port for export. Bulk product is expected to be transported using a fleet of quad road trains, each completing two trips per 12 hour shift. Up to 10 return truck movements per day will occur between the Mine Site and Derby Port, operating 24 hours per day 7 days per week.

Packaged mineral sands products (zircon concentrates and HiTi88 Leucoxene) will be transported by road train to the Port of Broome for export as Derby Port facilities do not allow for efficient transfer of packaged materials to ocean-going vessels. Existing port facilities including storage sheds will be used for storage and export of packaged products. Bulk products will be loaded into bulka bags or containers at the Mine Site prior to road transport.

The transport route from the Mine Site to Derby Port is approximately 145 km long with approximately 6 km of the transport route located in residential/commercial areas within Derby (the remaining 139 km are in unpopulated areas). The Great Northern Highway forms the longest portion of the transport route to Derby Port.

The transport route from the Mine Site to the Port of Broome is approximately 150 km long with approximately 12.5 km of the transport route using the dedicated heavy vehicle bypass route (Gubinge Road and Port Drive) to access the port. The Great Northern Highway forms the longest portion of the transport route to the Port of Broome.

The proposed Site Access Road and transport routes are shown in Figure 14.



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Original Size: A4
Satellite Image: Copernicus Sentinel Data 2016
Grid: Australia MGA94 (51)

0 10 km

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Figure 14

Proposed Product Transport Route from Mine Site Development Envelope to Export Locations

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MBS ENVIRONMENTAL

W:\Sheffield Resources\PER\Drawings\PER Map.map 22/12/2016 F14 Transport Route A4L

3.8 PRODUCT EXPORT

The estimated annual output of between 250,000 tpa to 600,000 tpa of bulk products from Derby (dependant on production year) will be loaded at an estimated average cargo size of 15,000 t per vessel leading to about 20 - 40 annual sailings, requiring an ocean-going vessel scheduled every 1 to 3 weeks.

Packaged products will also be exported from the Port of Broome at an estimated average cargo size of about 5,000 t per vessel with about 20 - 30 annual sailings anticipated depending on customer demands for packaged products.

Ocean-going vessels are unable to berth at Derby Port and need to be loaded at sea via transhipment vessels that will either be a self-propelled vessel or tug and transhipment vessel combination. This is the same system as Western Metals operated from the same facilities for lead/zinc concentrate export.

Ocean-going vessels can berth at the Port of Broome. Packaged products will be transferred via existing wharf or vessel cranes directly to ocean-going vessels.

Sheffield will not own or operate the transhipment vessels, but will engage commercial transhipment services under contractual arrangements. The following sections describe the infrastructure and activities.

3.8.1 Product Characteristics

Five final products (Ilmenite, Ilmenite LTR450, Primary Zircon, Zircon Concentrate and HiTi88 Leucoxene) will be produced for export from the site. A titano-magnetite concentrate produced as by-product of the ilmenite roasting stage may form a sixth saleable concentrate.

Materials are defined under the *Radiation Safety Management Act* 1975 as radioactive substances if they have a total radiation concentration greater than 1 Bq/g. This is outlined in the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) C*ode of Practice and Safety Guide for Radiation Protection and Radioactive Waste Management in Mining and Mineral Processing* (ARPANSA 2005). Materials with radiation concentrations of Naturally Occurring Radioactive Materials (NORM) greater than 10 Bq/g are required to have their transport regulated.

Bulk products (Ilmenite and Ilmenite LTR450) will not be classified as radioactive substances as their radiation concentrations will be less than 1 Bq/g. Packaged products (Zircon Concentrate, Primary Zircon and HiTi88 Leucoxene) will be classified as radioactive substances as their radiation concentration will exceed 1 Bq/g. No products will have a radiation concentration greater than 10 Bq/g and as such regulation of transport of products under the *Radiation Safety Management Act* from the Mine Site to the point of export will not be required.

Predicted radiation concentrations of total activity for the individual products to be exported are as below:

- Ilmenite = 0.59 Bq/g (0.0 Bq/g Uranium and 0.59 Bq/g Thorium).
- Ilmenite LTR450 = 0.50 Bq/g (0.0 Bq/g Uranium and 0.50 Bq/g Thorium).
- HiTi88 Leucoxene = 1.52 Bq/g (0.68 Bq/g Uranium and 0.84 Bq/g Thorium).
- Zircon Concentrate = 9.10 Bq/g (5.40 Bq/g Uranium and 3.70 Bq/g Thorium).
- Primary Zircon = 5.10 Bq/g (4.13 Bq/g Uranium and 0.97 Bq/g Thorium).

3.8.2 Derby Port Infrastructure

The Derby Port is an active facility and provides berthing services to transhipment vessel and landing craft tank operators working in and around King Sound and tourist boats that frequent the area. The Port has previously been used to export lead and zinc concentrates by a transhipment operation from the Western Metals Lennard Shelf lead zinc operations near Fitzroy Crossing (ceased 2008). Western Metals built a bulk storage facility at the port, but this has since been demolished and the site remains undeveloped. Western Metals also built ship-loading infrastructure including a shed-to-wharf conveyor belt structure and ship-loader which remain in place and form part of the Port assets.

Sheffield proposes to lease this land to build a new storage facility and reinstate the existing material handling equipment with some modifications (Table 12). A new product storage facility will be required to be constructed at the site of the previous storage facility, adjacent to the wharf. This will either be a fully enclosed, concrete-floored facility connected to existing mains power and water supplies or bulk product silos. If the product storage shed option is constructed, shed doors will only open to allow entry and exit of road trains. Maintaining dry products is important for product quality and value.

Table 12: Derby Port Infrastructure and Proposed Modifications

Infrastructure	Existing Infrastructure	Proposed Works
Storage Facility	No	The former mineral concentrate storage facility was decommissioned in 2011. Sheffield will construct a new 15,000 m^2 storage facility for storage of product prior to export.
Covered Conveyor to Ship Loader	Yes	To be retained and operated. Modification to hopper required and a new belt feeder to be added. All idlers, pulleys, drives, and motors to be replaced.
Ship Loader	Yes	To be retained. Head chute to be replaced.
Jetty Warehouse	Yes	One section of warehouse to be retained for use (other sections are held by other lessees).
Washdown Pad	No	Has been removed and will be replaced.
Administration Office and Ablutions	No	New administration offices, ablutions, and sampling laboratory to be added.
Power and Water	Yes	Transformer to be retained. Existing water supply to be retained. Switchboard to be replaced
Drainage and Stormwater Management	No	All materials to be stored within purpose built facility. Clean stormwater to be diverted around storage facility.
Mooring and Anchor Points	Yes	Department of Transport advised existing points likely degraded. Replace as required.

The majority of mineral product will be stored and exported from Derby Port as a bulk product, utilising a combination of existing and upgraded port facilities.

The existing infrastructure, and additional infrastructure to be constructed as part of the project, will be referred to as the Derby Port Development Envelope and is shown on Figure 15.

Refuelling of vessels will occur by the standard methods employed at Derby Port - mobile refuelling trucks with no refuelling infrastructure permanently sited on the wharf.

3.8.3 Port of Broome Infrastructure

The Port of Broome is an active port facility managed by Kimberley Ports Authority situated on the northwest shore of Roebuck Bay, close within the entrance to the bay. The Port is a major export outlet for cattle and a major supply base for fishing, pearling and vessels supporting the offshore oil and gas industry. Cruise and charter vessels are producing a growing industry.

The port is comprised of a 331 m long steel piled, concrete decked wharf structure with 12 individual berths. The wharf is fitted with a number of cranes to allow loading and unloading of product.

Sheffield proposes to lease a storage facility from existing vacant or underutilised facilities. This will be a fully enclosed, concrete-floored facility connected to existing mains power. Packaged product will either be transferred from trucks directly to an ocean-going vessel or placed within the storage shed and stored prior to arrival of an ocean going vessel.

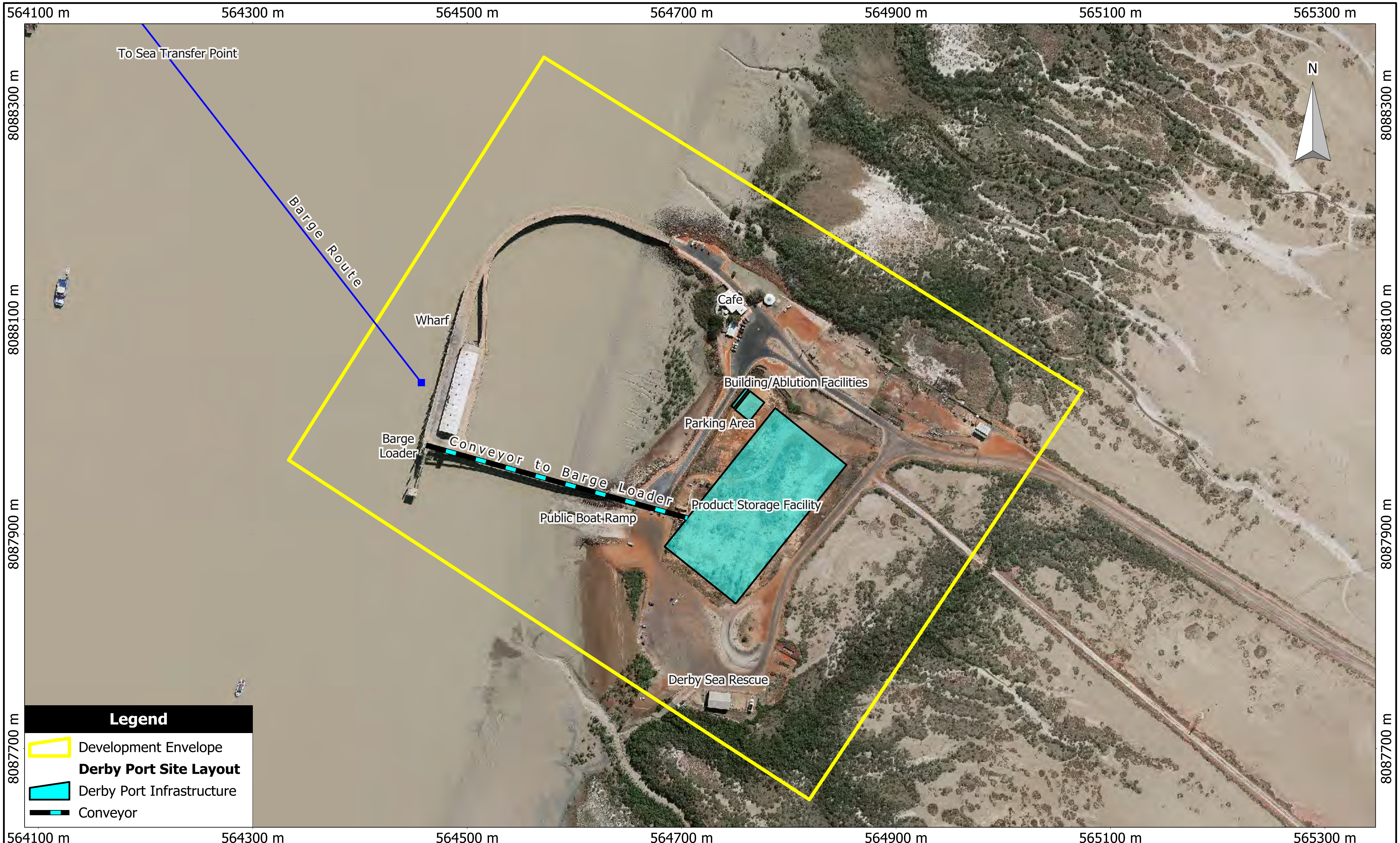
Existing wharf cranes and or vessel cranes will be used to transfer packaged product from trucks to an ocean-going vessel.

No additional product unloading, storage or loading infrastructure will be required to be constructed to allow export of packaged product from the Port of Broome.

3.8.4 Derby Vessel Zones

The same vessel zones for Derby will be utilised as those used by Western Metals. The three vessel zones (Figure 16) are:

- **Pilot Boarding Point:** To navigate the islands, headlands and shoals of King Sound, the ocean-going vessel will be boarded by a pilot. The pilot will navigate the ocean-going vessel to the sea transfer point within the port limits.
- **Sea Transfer Point:** The sea transfer point is where the ocean-going vessel will be moored to be loaded from the transhipment vessel. It is located in King Sound in around 20 metres of water (at low tide), 17.3 nautical miles (nm) from Point Torment and within the Port of Derby limits.
- **Wharf Mooring Zone:** The wharf mooring zone will be where the transhipment vessels (barges) and tug boats are accommodated on fixed moorings when not in use or while waiting to approach the wharf at a higher tide. The existing mooring zone is ~6 nm from Derby wharf.



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Original Size: A4
Air Photo: Landgate 2015
Grid: Australia MGA94 (51)

0 100 m

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Figure 15

Derby Port Development Envelope

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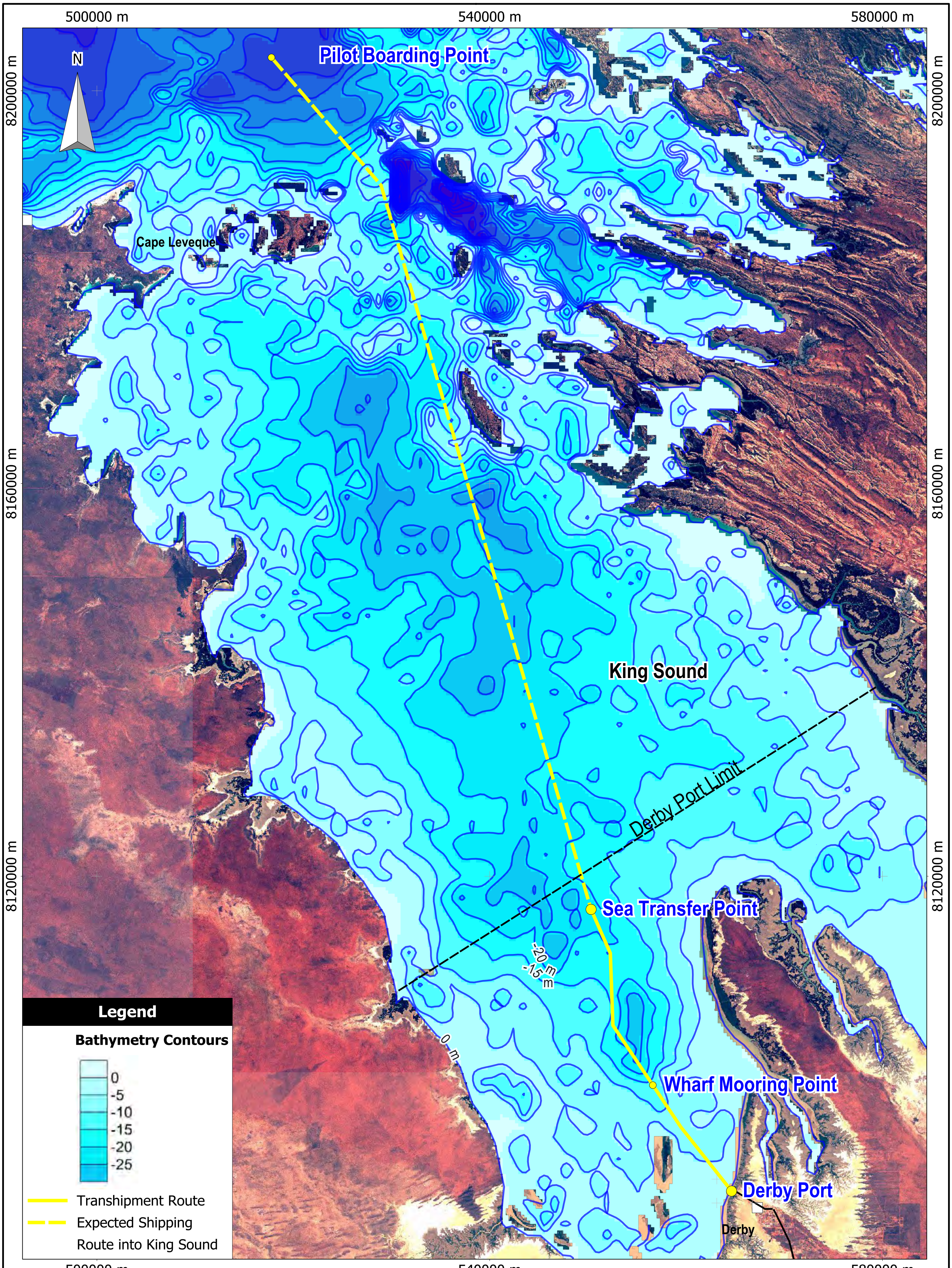

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Original Size: A4
Satellite Image:2016 Copernicus Sentinel Data
Grid: MGA94(51)

0 10 km

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Figure 16

Derby Port Mooring and Anchor Points

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3.8.5 Derby Port Transhipment Vessels

Transhipment vessels (barges) with up to 5,000 tonne capacity (Plate 1) will be used to move bulk product between Derby wharf and the sea transfer point. It is likely that tugs will be used to manoeuvre the transhipment vessel, but over the life of the project, it is also possible that self-powered vessels could be used. Transhipment vessels will be moved:

- When fully loaded to the sea transfer point when an ocean-going vessel arrives and is ready to be loaded.
- From the wharf to the wharf mooring zone when the tide is too low to continue loading.
- From the wharf mooring zone to the wharf when the tide has come up to continue loading.

Plate 1: Typical Transhipment Vessel with Tugboats

3.8.6 Derby Transhipment Vessel Loading

The daily loading of the transhipment vessel can only occur when the tide is sufficiently high to allow the transhipment vessel to berth at the wharf, allowing for approximately two six-hour loading periods per 24 hours. The existing conveyor system will be renovated and upgraded for use by Sheffield. The existing loading conveyor at the wharf is covered to minimise dust and loss of product to King Sound.

3.8.7 Derby Ocean-going Vessel Loading

The ocean-going vessel will have its own cranes (i.e. geared) for loading of bulk product from the transhipment vessel similar to the vessel shown in Plate 2. Handysize vessels with a deadweight of up to 35,000 tonnes will be used for shipping mineral sands products, with the average vessel size anticipated to have a deadweight of around 15,000 to 35,000 t. Loading is estimated to take up to a maximum of seven days based on an approximate 5,000 t per day loading rate (Table 13).

Plate 2: Typical Ocean-going Vessel Loading

3.8.8 Materials Handling Schedule

An overview of proposed product transport and transhipment schedule is provided in Table 13.

Table 13: Materials Handling Schedule

Activity	Daily Hours of Operation	Schedule
Derby Port (Bulk Products)		
Transport of product from Mine Site to Derby Port	24	Estimate 10 truck return journeys per day. 7 days per week
Product Storage Facility	24	7 days per week
Transhipment Vessel Loading	2 x 6 hour periods per day	Approximately 6-10 days per month, subject to tides
Ocean-going Vessel Loading	3 days on average (7 days maximum) to load, operating 24 hours per day	2 - 4 shiploads per month
Port of Broome (Packaged Products)		
Transport of product from Mine Site to Port of Broome	24	Estimate 7 truck return journeys per day. 7 days per week
Packaged Product Storage Facility	24	7 days per week
Ocean-going Vessel Loading	24	2 - 4 shiploads per month

3.9 REHABILITATION AND CLOSURE

Rehabilitation and closure will be implemented as described in this document and subsequent Mine Closure Plans as required under the *Mining Act 1978*.

Backfilling, landforming, and revegetation will be used to create post-mining landforms that are consistent with the surrounding landscape. The mining area is likely to be slightly elevated from current topography due to the natural swell factor that applies to excavated material (Figure 8). The initial TSF will be shaped and rehabilitated in-situ to remain as the only post-mining landform.

All required infrastructure will be decommissioned, removed and footprints rehabilitated.

When the shipment of mineral sands products ceases, the Port site will be closed and rehabilitated in accordance with the lease conditions and the requirements of any future lessee.

Section 12 provides further detail on the rehabilitation and decommissioning aspect of the Mine Site Development Envelope.

A Mine Closure Plan has been developed for the project and is provided in Appendix 4.

3.10 WORKFORCE

The project construction phase will require a workforce of approximately 500 people which will reduce to around 150 people once the project is operational. The project will be staffed preferentially by drive in, drive out personnel sourced locally from Derby, Broome, and surrounding areas where possible, who will be accommodated on site for their work roster. If additional or specialised workforce is required which cannot be sourced locally, personnel will be flown to either Derby or Broome airports and will be accommodated on site.

4. EXISTING ENVIRONMENT

4.1 ENVIRONMENTAL STUDIES

Numerous studies and investigations have been undertaken within the Mine Site Development Envelope and Derby Port Development Envelope in order to provide a comprehensive overview of the existing environment and to identify any potential impacts that may occur as a result of the Thunderbird Mineral Sands Project. These are presented in Table 14.

Table 14: Studies Undertaken for the Thunderbird Mineral Sands Project

Environmental Factor	Report Title	Report Author	Date Completed
Mine Site Factors			
Flora and Vegetation*	Thunderbird Dampier Peninsula Project Level 1 Flora and Fauna Assessment	Ecologia	2012a
	Thunderbird Project Level 2 Flora and Vegetation Report	Ecologia	2014b
	Thunderbird Project Haul Road and Accommodation Village Flora and Fauna Assessment	Ecologia	2015
	Flora and Vegetation of the Thunderbird Mineral Sands Project Area	Mattiske	2016a
	Potential Groundwater Dependent Ecosystems in the Thunderbird Mineral Sands Project Area	Mattiske	2016b
Terrestrial Fauna*	Thunderbird Dampier Peninsula Project Level 1 Flora and Fauna Assessment	Ecologia	2012a
	Thunderbird Project Level 2 Terrestrial and Subterranean Fauna Assessment	Ecologia	2014a
	Thunderbird Project Haul Road and Accommodation Village Flora and Fauna Assessment	Ecologia	2015
	Thunderbird Project Targeted Greater Bilby Assessment	Ecologia	2016
Hydrological Processes* Inland Waters Environmental Quality*	Thunderbird Surface Hydrology	MBS	2016a
	H3 – Level Hydrogeological Assessment of the Thunderbird Project	Rockwater	2016
Heritage*	Final open Report. Nyikina Mangala Native Title Claim Group and Other Traditional Owners. Survey of Tenement E04/2083, Mt Jowlaenga. Confidential Report.	Cox Anthropology	2012
	Ethnographic Heritage Survey Report - Open Survey of Tenement E04/2081,2083-84,2159, 2191-94, 2171: Mt. Jowlaenga. Confidential Report.	Beit Holmes and Associates	2013
	Ethnographic Heritage Survey Report - Open Survey of Tenements E04/2081, 2083-84, 2159, 2171, 2191-94: Mt Jowlaenga. Confidential Report.	Beit Holmes and Associates	2014
	Ethnographic Heritage Survey Report - Open Survey of Tenements E04/2083-84, 2159, 2171, 2192-94, 2349: Mt. Jowlaenga. Confidential Report.	Beit Holmes and Associates	2015
	Ethnographic Heritage Survey Report - Open Survey of MO4/459 within EO4/2083: Thunderbird Project proposed Mining Operations Area. Confidential Report.	Beit Holmes and Associates	2016a

Environmental Factor	Report Title	Report Author	Date Completed
	Ethnographic Heritage Survey Open Report – BFS Activities Mt Jowlaenga Polygon #2 May 2016. Confidential Report.	Beit Holmes and Associates	2016b
Rehabilitation and Decommissioning*	Thunderbird Mine Waste Characterisation	MBS	2016b
	Thunderbird Soil and Landform Assessment	MBS	2016c
	Revised Radionuclide Mass Balance and Regulatory Summary	SGS	2016
Landforms	Thunderbird Soil and Landform Assessment	MBS	2016c
Subterranean Fauna	Thunderbird Project Level 2 Terrestrial and Subterranean Fauna Assessment	Ecologia	2014a
Terrestrial Environmental Quality	Thunderbird Mine Waste Characterisation	MBS	2016b
	Revised Radionuclide Mass Balance and Regulatory Summary	SGS	2016
	Geotechnical Report	Hatch	2016
Air Quality and Atmospheric Gases	Thunderbird Mine Site Air Quality Assessment	Atmospheric Solutions	2016a
Human Health	Revised Radionuclide Mass Balance and Regulatory Summary	SGS	2016
	Radionuclide Mass Balance	Radiation Professionals	2016
	Investigations as for 'Air Quality and Atmospheric Gases'		
Derby Port Development Envelope			
Amenity*	Product Transport and Derby Port Air Quality Assessment	Atmospheric Solutions	2016b
	Environmental Noise Impact Assessment – Port of Derby	WSP | Parsons Brinckerhoff	2016a
Hydrological Processes	This Public Environmental Review (Section 4.2.6 and Section 4.3.8)	MBS	2016 (this PER)
Marine Environmental Quality*	Revised Radionuclide Mass Balance and Regulatory Summary	SGS	2016
	Thunderbird Mineral Sands Project Derby Export Facility Baseline Contamination and Acid Sulfate Soil Assessment	MBS	2016
Benthic Communities and Habitat	This Public Environmental Review (Section 4.3.13)	MBS	2016
Terrestrial Environmental Quality	Investigations as for 'Human Health' and 'Amenity'		
Human Health	Revised Radionuclide Mass Balance and Regulatory Summary	SGS	2016
	Radionuclide Mass Balance	Radiation Professionals	2016
	Investigations as for 'Amenity'		

** = Key Environmental Factor*

4.2 MINE SITE DEVELOPMENT ENVELOPE

This section describes information regarding the physical, biological and socio-economic characteristics of the proposed Mine Site Development Envelope. This includes all information gathered during physical and biological surveys conducted for the project for this area.

4.2.1 Regional Setting

The Mine Site Development Envelope is located on the Dampier Peninsula in the western part of the Kimberley region, within the Dampierland bioregion and Pindanland subregion as defined by the Interim Biogeographic Regionalisation of Australia (IBRA) classification system (Graham 2001). The Pindanland subregion (5,198,904 ha) is described as a fine-textured sand-sheet with subdued dunes, comprised of the sandplains of the Dampier Peninsula and western part of Dampierland, including the Fitzroy River paleodelta. The climate is semi-arid and vegetation is primarily described as Pindan. Broad scale vegetation mapping of the Pindanland subregion describes the following components:

- Mangroves around coastal areas.
- Coastal dune communities.
- Ephemeral herblands and/or grasslands with scattered low trees.
- Mixed species tussock grasslands or sedgelands.
- Various Eucalypt and Melaleuca woodlands.

The topography largely consists of flat sandy plains with some small rock hills approximately 50 m high. The rocky hills are confined to an area of approximately 3 km^2 between the proposed operations and accommodation village areas. The gradient of the plains is flattest to the west of the Mine Site Development Envelope (averaging approximately 0.75%) tending to increase to approximately 1% to the east (MBS 2016a).

4.2.2 Climate

The climate of the Mine Site Development Envelope is classified as 'grassland, hot (winter drought)' under the modified Köppen classification for Australia (Stern et. al. 2000). It has summer dominant rainfall, with hot, humid summer temperatures (BoM 2016a).

4.2.2.1 Temperature, Evaporation and Humidity

Most rainfall occurs during the wet season between November and April. Potential evapotranspiration is very high, averaging 1,980 mm per year, and varies moderately across seasons. Evapotranspiration generally remains higher than rainfall even in the wet season, resulting in water limited conditions for vegetation (CSIRO 2009).

Weather data has been collected from an automatic weather station at the Mine Site Development Envelope since November 2014. Monthly maximum and minimum temperatures and mean humidity are shown in Chart 1. Maximum temperatures are generally between 33°C and 45°C, with minimum temperatures rarely dropping below 15°C during the dry season. Average humidity is around 40% in the dry season and approaches 80% in the wet season. Days with maximum humidity over 90% were observed in all months.

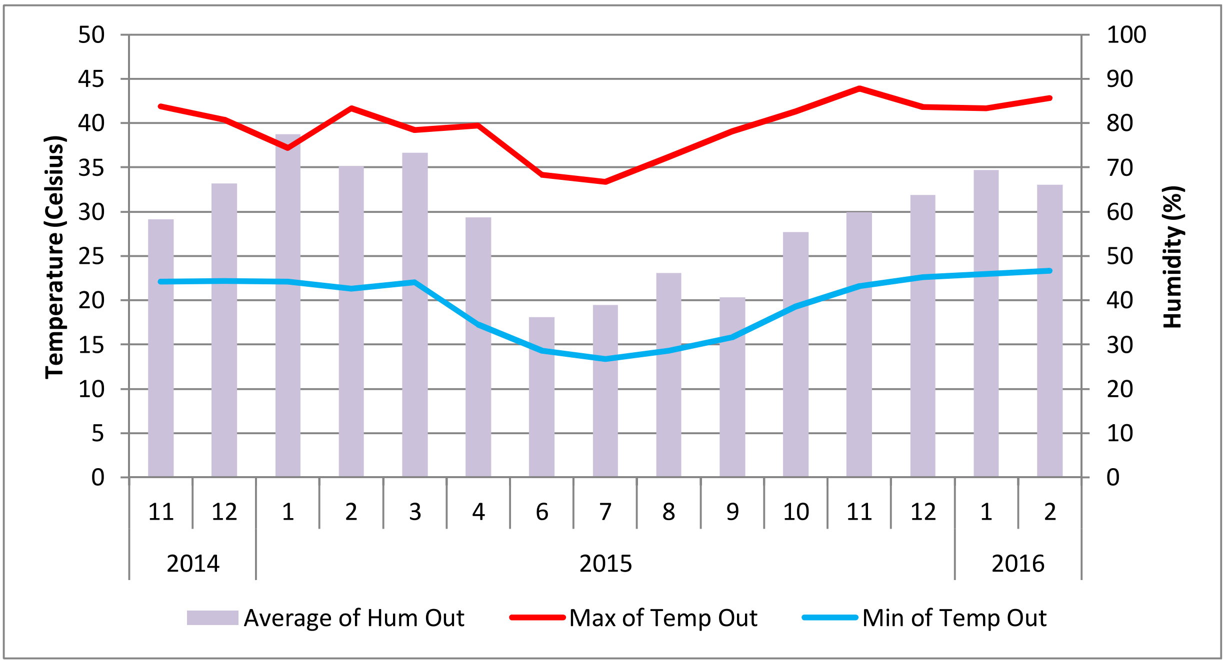


Chart 1: Temperature and Humidity at Mine Site Development Envelope

4.2.2.2 Rainfall

Spatially extrapolated rainfall data is available for the Mine Site Development Envelope from the SILO Data Drill data set (Queensland Government 2016). This data is calculated by extrapolation from all available Bureau of Meteorology (BoM) data including the closest BoM sites (Thunderbird, Mt Jowlaenga, Country Downs, Beagle Bay, Yeeda, and Derby Aero) to give a continuous estimated record for a specific location. Comparison with local stations shows that the data drill closely matches Mt Jowlaenga rainfall records (when available), and is similar to Country Downs and other nearby stations at other times. It is recommended this dataset be used for long term rainfall patterns.

Monthly rainfall statistics for the Mine Site Development Envelope based on the Data Drill dataset from 1889 to 2015 are shown in Table 15 and Chart 2, with annual figures based on a rainfall year from September to August. Mean annual rainfall is 694 mm, however, is very variable with a lowest annual rainfall of 153 mm and highest of 1,503 mm. Median annual rainfall is 675 mm. Median monthly rainfall is 1.2 mm or less during the dry season from May to October. Very low or zero rainfall may occur in any month. Details on modelled estimated rainfall from extreme events is described in Appendix 5.

Table 15: Rainfall Statistics for Mine Site Development Envelope 1889 to 2015 (Data Drill)

Month	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Annual
Mean	1.0	3.9	17.8	92.4	193.1	181.0	128.9	29.9	23.4	14.9	6.5	3.5	695.3
Highest	48.5	53.9	229.1	668.5	1031.8	556.9	535.1	261.7	308.4	159.4	157.6	56.1	1502.7
Decile 9	1.1	12.0	44.3	181.4	365.3	334.9	288.1	73.5	80.6	53.7	19.8	5.9	1003.6
Median	0.0	0.3	8.4	66.1	156.6	164.7	96.7	12.4	0.9	0.3	0.0	1.2	675.2
Decile 1	0.0	0.0	0.3	10.8	54.7	47.0	26.0	0.0	0.0	0.0	0.0	0.7	401.2
Lowest	0.0	0.0	0.0	1.1	21.0	12.7	1.8	0.0	0.0	0.0	0.0	0.5	152.6

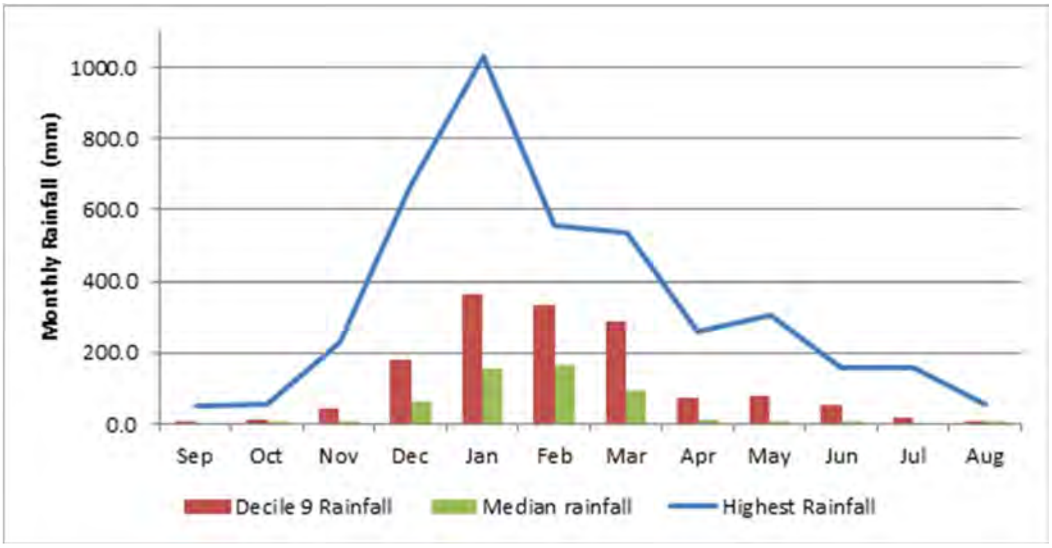


Chart 2: Monthly Rainfall Statistics for Mine Site Development Envelope

4.2.2.3 Wind Speed and Direction

The closest BoM site with wind speed records is Derby Aero (Site 003032). A summary of wind speeds for the Derby BoM site and Thunderbird weather station are presented in Table 16. Morning wind directions tend to be from the east between April and August and from the northwest between September and March. Afternoon wind directions are predominantly from the northwest all year round with the exception of May and June when wind from the southeast is also likely (BoM 2016b).

Table 16: Mean Wind Speeds (km/h)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Derby Aero (BoM Site 003032)													
9 am	13.1	11.8	11.2	10.9	13.7	14.6	14	13	12.9	13	12.7	12.7	12.8
3 pm	18.6	16.5	15.1	14.8	14.8	14.7	15.4	16	19.1	23	24.1	22	17.8
Thunderbird Weather Station													
9 am	8.0	5.6	5.8	5.9	-	7.2	8.5	8.7	8.5	7.1	8.4	7.8	7.4
3 pm	6.2	7.2	6.5	8.4	-	7.7	8.0	7.9	9.6	8.3	7.8	8.2	7.8

4.2.2.4 Tropical Cyclones

Across the Kimberley region widespread rainfall event total volumes in excess of 100 mm are commonly associated with tropical lows and cyclones. Such rainfalls can occur well to the east of the cyclone due to moisture-laden northwesterly monsoon winds. Rainfall is not directly related to the intensity of the cyclone and some of the largest flood events have been associated with tropical lows below cyclone intensity.

Although rainfall associated with tropical cyclones is a likely contributor to flooding in the inland Mine Site Development Envelope, cyclone risk with respect to wind is much lower than for Broome and coastal Pilbara towns due to fewer cyclones, including severe cyclones, impacting on the area. On average, for the northwest coast as a whole, approximately five cyclones occur each year, two of which cross the coast with one rated as severe (BoM 2016c). When taken in isolation, the risk of a cyclone occurring at any particular location inland from the coast is much lower. Figure 17, shows the tracks of some notable cyclones affecting the Dampier Peninsula (BoM 2016c).

The cyclone season officially runs between November and April, although cyclones only rarely occur in November and have been observed as late as May. The highest risk of category 4 or 5 cyclones is late in the season during March and April. The impact of early cyclones on flooding is also likely to be lessened due to dry catchment conditions.

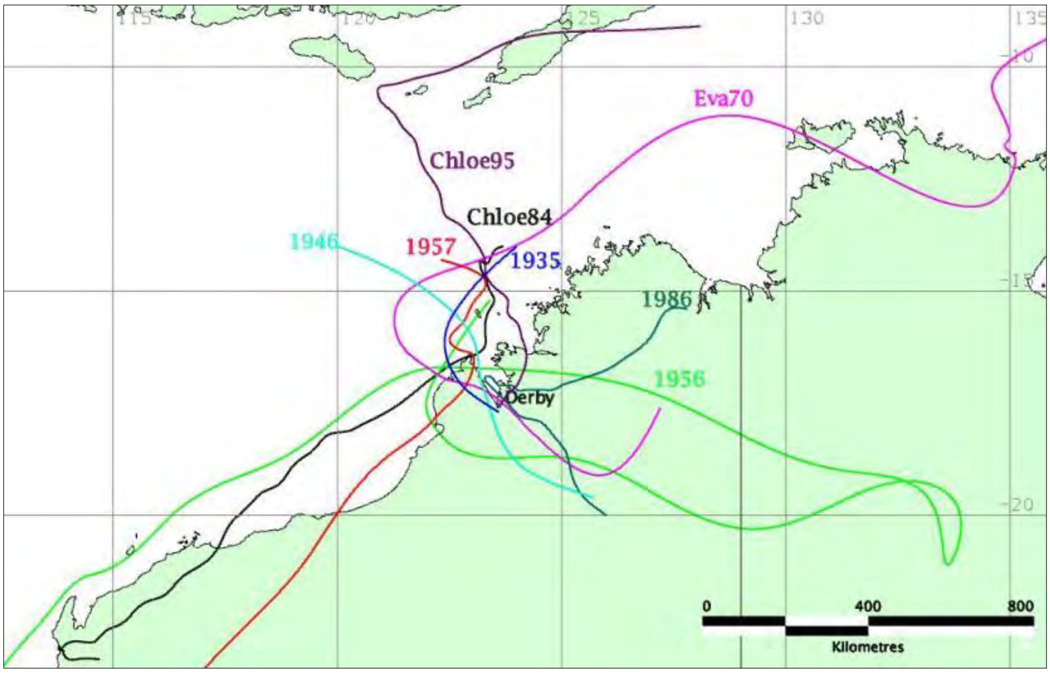


Figure 17: Tracks of Notable Cyclones Affecting the Mine Site Development Envelope

4.2.3 Geology

4.2.3.1 Regional Geology

The Mine Site Development Envelope is located in the west Kimberley on the Dampier Peninsula, located within the Fitzroy Trough in the north of the Phanerozoic Canning Basin, an intracratonic basin covering 640,000 km^2 with a dominant onshore area of 530,000 km^2.

The Fitzroy Trough is bounded by the Beagle Bay Fault in the north and the Fenton Fault in the south (Figure 18), which are near-vertical normal faults (Searle 2012). The faults extend through the Triassic and older sediments. The faults' prevalence in younger sediments is unknown. The major fold within the Trough is the Baskerville Anticline, in the centre of the Dampier Peninsula. The anticline strikes east-west and plunges to the west. Strata on the southern limb dip gently to the south-west and strata on the northern limb dip gently to the northwest.

The main geological units of interest in the Dampier Peninsula are the Broome Sandstone and the Mowanjum Sand (Table 17). The Broome Sandstone is mainly concealed at the surface by the younger units, however it does outcrop at some locations across the Peninsula, mostly along the shoreline. Outcrops of various facies of the Broome sandstone have been mapped near the Mine Site Development Envelope (Figure 18).

Table 17: Stratigraphy of the Dampier Peninsula

Age	Formation	Maximum Thickness (m)	Lithology	Extent
Quaternary	Mowanjum Sand ('Pindan')	10	Fine-grained (very fine to medium) silty sand.	Widespread across the peninsula
Late Cretaceous	Emeriau Sandstone	30	Fine- to coarse-grained poorly sorted sandstone, minor conglomerate, commonly ferruginous.	North-west of the peninsula only near Bobbys Creek and Lollywell Springs
Early Cretaceous	Broome Sandstone	384*	Fine- to coarse-grained sandstone, gravel, some siltstone, mudstone and conglomerate. Heavy minerals near top & base.	West and central part of the Dampier Peninsula, except where it has been eroded away towards the east.
Late Jurassic	Jarlemai Siltstone	240	Shallow marine laminated pink and purple siltstone with a sugary texture, massive and partly sandy mudstone, limestone. Includes thin coal seams.	Underlies the whole of the study area.

** The unit follows Towner and Gibson's (1980) usage and includes the "Jowlaenga Formation" basal transitional unit.*
Source (after Rockwater 2016)

4.2.3.2 Local Geology

Mowanjum Sand

The Mowanjum Sand (Searle 2012) occurs at the surface or beneath a veneer of other superficial units within the Dampier Peninsula. It is a widespread sheet deposit of Quaternary age and unconformably overlies a weathered contact on the Broome Sandstone. It is overlain itself by thin younger deposits in places. Various other unconsolidated deposits of sand, limestone, silt, clay, gravel, and conglomerate occur along beaches, and tidal flats, and are associated with the dunes. The unit consists of red-brown, fine-grained (very fine to medium) silty sand (colloquially termed 'Pindan'), and is generally between 8 and 14 m thick (maximum 29 m) in the holes drilled by Wright (2013) near the Broome townsite. At the Mine Site Development Envelope it is typically 6 to 12 m thick and unsaturated.

Emeriau Sandstone

The Emeriau Sandstone consists of fine- to coarse-grained, poorly sorted sandstone and conglomerate. It is of Late Cretaceous age and is only present in the northwest of the Dampier Peninsula, about 60 km northwest of the Mine Site Development Envelope. It overlies the Broome Sandstone.

Broome Sandstone

The Broome Sandstone is present over the west and central part of the Dampier Peninsula, except where it has been eroded away towards the east and over the nose of the Baskerville anticline. To the west, the Broome Sandstone extends offshore beneath the Indian Ocean.

The unit description here follows Towner and Gibson's (1980) usage and includes the basal transitional unit known as the Jowlaenga Formation. The sediments of the Broome Sandstone and basal Jowlaenga Formation are of Early Cretaceous age. They are overlain by superficial units comprising shoreline, aeolian, and alluvial deposits; mainly the Mowanjum Sand ('Pindan sand'). The contact with the Mowanjum Sand is weathered and is frequently difficult to recognise in drill cuttings. The Broome Sandstone is underlain by the Jarlemai Siltstone, which is of Late Jurassic to Early Cretaceous age and has a maximum onshore recorded thickness of 388 m (DMP 2016b).

Broome Sandstone (Upper)
The Broome Sandstone consists of weakly cemented, fine- to coarse-grained quartzose sandstone, with minor beds of siltstone and claystone, thin coal seams, and minor pebble conglomerate (Laws 1991). Vogwill (2003) reports that these lithologies are contained within four subfacies, three upper deltaic facies ('Broome Sandstone 1–3') and a lower fluvial subfacies ('Broome Sandstone 4') in the southwest of the Peninsula. The fluvial facies comprises mainly coarse grained sand and granule-sized particles with minor siltstone and claystone, while the upper deltaic facies is mainly medium- to coarse-grained sand with abundant silt. The Broome Sandstone is characterised in geophysical logs by low gamma radiation and high resistivity where the formation is saturated by fresh groundwater. Gamma-radiation signatures have higher intensity where there are intercalated siltstone and claystone beds. Gamma-radiation signatures have lower intensity where pebble conglomerate beds are present.

Heavy Mineral Sands
At the Mine Site Development Envelope, the lower part of the Broome Sandstone comprises high grades of fine-grained heavy mineral sands (HMS), containing valuable heavy minerals ilmenite, zircon, leucoxene and rutile. Mineralisation is in a thick, broad, anticlinal, sheet-like body striking northwest. The HMS section of the Broome Sandstone in the Mine Site Development Envelope is relatively thick (35–55 m). The HMS lithology of the Broome Sandstone is comparably finer-grained to that of the upper section of the Broome Sandstone. The areal extent, width, grade, geological continuity and grain size of the Thunderbird deposit are interpreted to indicate an off-shore sub-wave base depositional environment.

Basal Transitional Unit
The Broome Sandstone basal transitional unit (also referred as the Jowlaenga Formation) is very similar lithologically to the upper part of the Broome Sandstone although it contains more silts and clays. It can be difficult to differentiate in drill cuttings; however, the transition is recognisable in geophysical logs by a progressive increase in gamma-intensity and a decrease of resistivity with depth. Resource exploration drilling data show an increased concentration of very-fine grained sediment (slime) in the basal transitional unit.

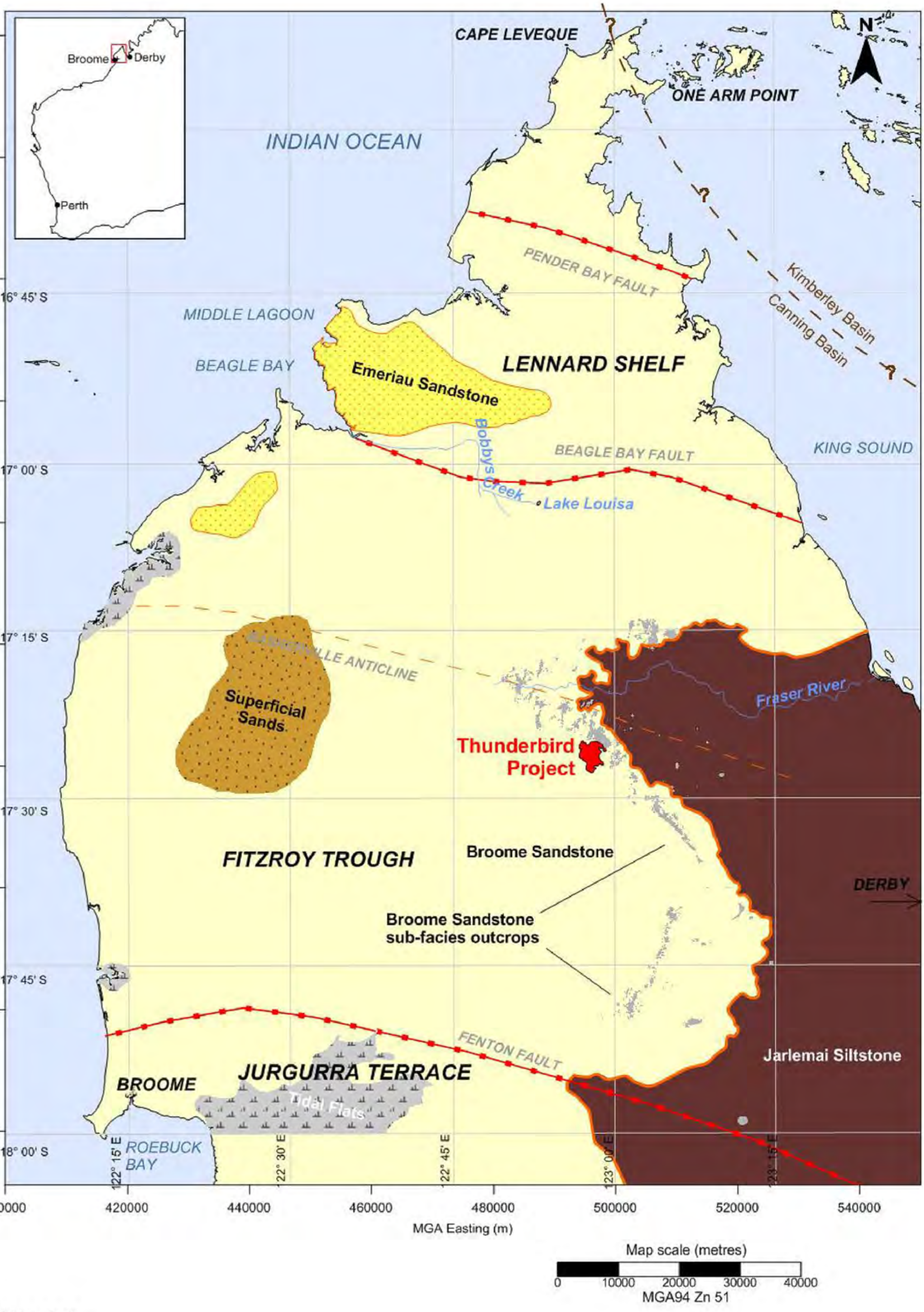
The transitional unit has been interpreted as generally 15–30 m thick (Rockwater 2016), in general agreement with the maximum recorded thickness of 40 m for the Jowlaenga Formation in Geoscience Australia's online geological database.

Jarlemai Siltstone

The Jarlemai Siltstone is a shallow marine deposit of early Cretaceous to late Jurassic age that is unconformably overlain by the Jowlaenga Formation (Gibson 1983). The formation is up to 218 m thick (in the bore Fraser River 1) and has an average thickness of about 100 m in the Dampier Peninsula.

The formation is primarily a mudstone, consisting of silty claystone, sandy and fossiliferous siltstone, and clayey sandstone. The siltstone and claystone are micaceous and pyritic. They are generally medium to dark grey, brownish grey, and light brown, but can be oxidised dark red-brown, purple, and yellow. Sands are light grey, coarse- to medium-grained, loose to friable, sub-rounded to rounded. Shell fragments, including pelecypods, brachiopods and foraminifera are common, and the formation is calcareous through the middle portion.

Structure contours on the top of the Jarlemai Siltstone indicate an asymmetric east-west trending anticline that probably developed over the pre-existing Baskerville anticline (Laws 1991). Some erosion may also have occurred, particularly south of the Mine Site Development Envelope, but the overall structure is an anticline-like feature.



CAPE LEVEQUE
ONE ARM POINT
INDIAN OCEAN
Broome
Derby
Perth
PENDER BAY FAULT
Kimberley Basin
Canning Basin
MIDDLE LAGOON
BEAGLE BAY
Emeriau Sandstone
LENNARD SHELF
Bobbys Creek
BEAGLE BAY FAULT
KING SOUND
Lake Louisa
ANTICLINE
Superficial Sands
Fraser River
Thunderbird Project
FITZROY TROUGH
Broome Sandstone
DERBY
Broome Sandstone sub-facies outcrops
FENTON FAULT
Jarlemai Siltstone
BROOME
JURGURRA TERRACE
Tidal Flats
ROEBUCK BAY
16° 45' S
17° 00' S
17° 15' S
17° 30' S
17° 45' S
18° 00' S
122° 15' E
122° 30' E
122° 45' E
123° 00' E
123° 15' E
8190000
8170000
8150000
8130000
8110000
8090000
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440000
460000
480000
500000
520000
540000
MGA Easting (m)
Map scale (metres)
0
10000
20000
30000
40000
MGA94 Zn 51

4.2.4 Land Systems, Landforms and Soils

A baseline soil and landform assessment was undertaken for the Mine Site Development Envelope (Appendix 6).

4.2.4.1 Land Systems

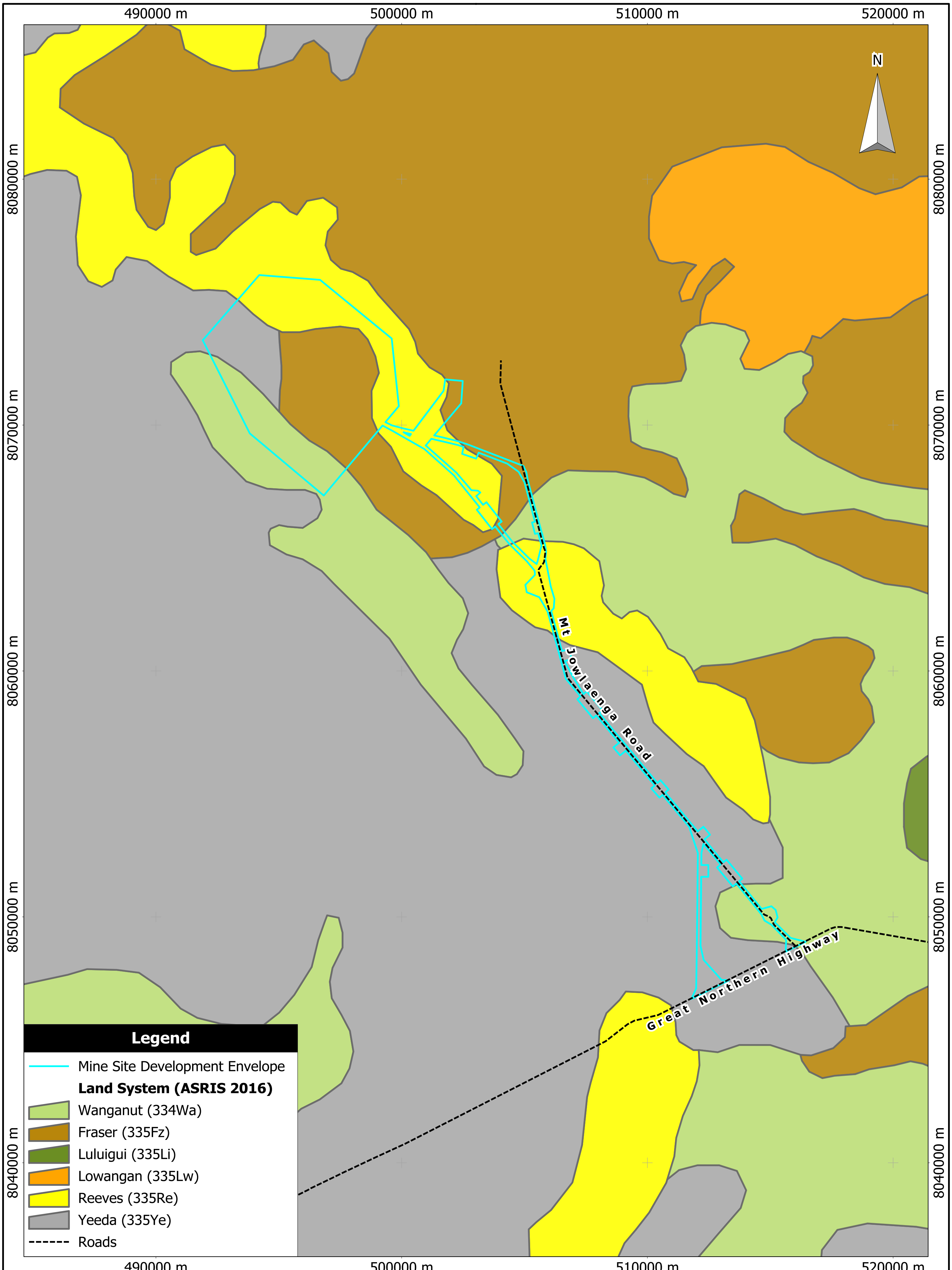
Nine land systems have been identified within the eastern Dampier Peninsula (Figure 19) (Payne and Schoknecht 2011; Australian Soil Resources Information System [ASRIS] 2016), four of which are located within the Mine Site Development Envelope:

- The Fraser land system (ASRIS mapping unit 335Fz) - characterised by sandplains and dunes with Pindan woodlands and spinifex/tussock grasslands.
- The Reeves land system (ASRIS mapping unit 335Re) - characterised by sandplains, scattered hills and minor plateaux.
- The Wanganut land system (ASRIS mapping unit 335Wa) - characterised by low-lying sandplains and dunefields with through-going drainage.
- The Yeeda land system (ASRIS mapping unit 335Ye) - characterised of sandplains and occasional dunes.

Summaries of geomorphology, surficial geology and vegetation characteristics of these land systems are presented in Table 18.

The sensitivity of land systems to damage or degradation has been considered. The Waganut and Yeeda land systems are subject to frequent fires, but generally not prone to degradation or erosion (Payne and Schoknecht 2011). The Reeves land system contains Pindan vegetation, which is subject to frequent fires. The sandplains and sand dunes are moderately susceptible to wind erosion after fire, but stabilise after rain (Payne and Schoknecht 2011). Similar to the Reeves land system, the Fraser land system is generally stable with low susceptibility to erosion except for sand dunes, which are moderately susceptible after fire but stabilise after rain.

The land systems are generally not prone to degradation or erosion by pastoral activities, provided grazing pressure is controlled and frequency of burning is maintained (Appendix 6). As livestock will be excluded from the project area, risk of degradation within undisturbed areas will be reduced.



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Original Size: A4
Grid: MGA94(51)

0 4 km

Sheffield Resources Limited
Thunderbird Mineral Sand Project

Figure 19

Land Systems of the Dampier Peninsula

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Table 18: Characteristics of Major Regional Land Systems (ASRIS 2016)

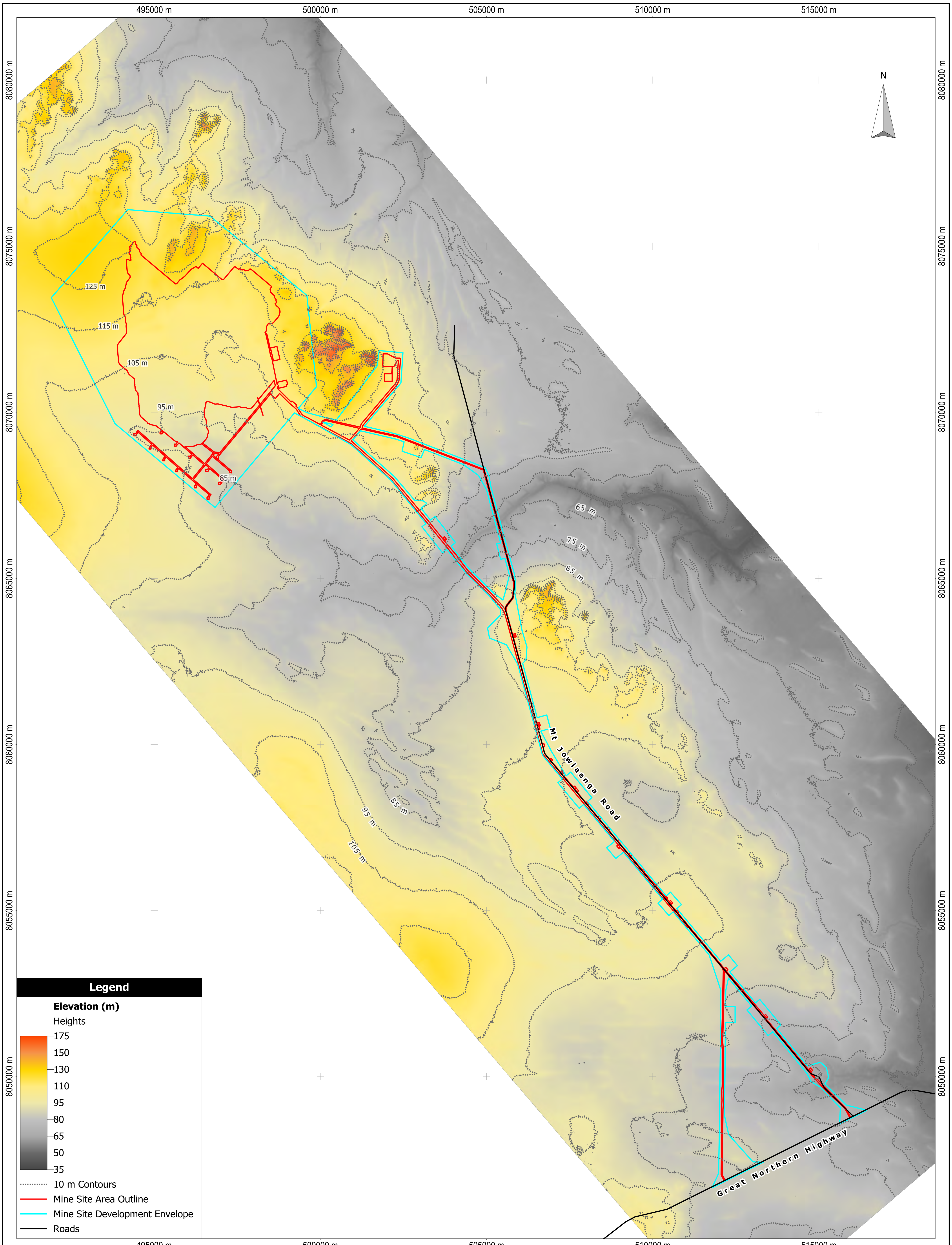
Land System	Geomorphology	Geology	Vegetation	Land Management	Significant Values
Fraser	Sandplain and dunefields with through-going drainage, sandplain with irregular dunes, plains with thin sand cover and local outcrop, low-lying sandplain flanking drainage features. Relief less than 9 m.	Quaternary aeolian sand and minor outcrops of gently dipping Cretaceous sandstones.	Pindan woodlands and spinifex/tussock grasslands.	Generally stable with low susceptibility to erosion except for sand dunes, which are moderately susceptible after fire, but stabilise after rain.	No known scientific or evolutionary values associated with this land system.
Reeves	Formed by dissection of the Kimberley surface - scattered hills, dip slopes with thin sand cover and local outcrop and sandplain. Sparse branching drainage pattern. Relief to 60 m.	Subhorizontal or gently dipping sandstone, silty sandstones and silicified sandstones of Cretaceous age. Quaternary aeolian sand.	Pindan woodlands and spinifex/tussock grasslands.	Pindan vegetation subject to frequent fires. Sandplains sand dunes are moderately susceptible to wind erosion after fire, but stabilise after rain.	No known scientific or evolutionary values associated with this land system.
Waganut	Sandplain and dunefields with through-going drainage, sandplain with stable dunefields, scattered pans and depressions. Sparse to moderately dense branching drainage pattern. Relief less than 9 m.	Quaternary aeolian sands.	Pindan woodlands and spinifex/tussock grasslands. Dense wattle scrub.	Subject to frequent fires, but generally not prone to degradation or erosion.	No known scientific or evolutionary values associated with this land system.
Yeeda	Sandplains and dunefields with little organised drainage.	Quaternary aeolian sands.	Shrubby spinifex grasslands and Pindan woodlands.	Subject to frequent fires, but generally not prone to degradation or erosion.	No known scientific or evolutionary values associated with this land system.

4.2.4.2 Landforms

Topography within the Mine Site Development Envelope is relatively subdued, with elevations ranging between 89 and 119 m RL AHD (Australian Height Datum), with an average elevation of approximately 110 m RL AHD (Figure 20). Rocky hills associated with the Reeves Land System occur as outcrops of shallow dipping Cretaceous sediments cover approximately 20% of the Mine Site Development Envelope. Plate 3 shows a typical low hilly landscape within the Reeves Land System.

Plate 3: Typical Low Hill Landform of the Reeves Land System

The deposit area experiences relatively even change in elevation along its length, from 130 m in the north to 95 m in the south. To the south of the deposit area, the Site Access Road crosses an area that is relatively low lying between two outcroppings, and then continues to undulate gently until reaching the Great Northern Highway.



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Original Size: A3
Grid: Australia MGA94 (51)

0 4 km

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Thunderbird Mineral
Sands Project

Figure 20

Topography of Mine Site Development Envelope

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Local Assessment Unit

The EPA's definition of landform is a distinctive, recognisable physical feature of the earth's surface having a characteristic shape produced by natural processes (EPA 2015g). For the purpose of defining the local assessment unit (LAU), the landforms in the area within and surrounding the Mine Site Development Envelope were derived through the use of contour line data and development of a GIS digital elevation model (full methodology provided in Appendix 7).

From an initial review of regional contours surrounding the Mine Site Development Envelope (up to 30 km away), it is clear that the most distinctive landforms in relation to the Mine Site Development Envelope are a north-west to south-east trending band of low hills parallel to the Mine Site Development Envelope associated with the Reeves Land System. This area was therefore selected as the focus of the LAU. The distinctive landform features within the band are Reeves Hill, Dampier Hill, Mt Jowlaenga and several unnamed smaller hills to the east and north of the Mine Site Development Envelope (Figure 21). None of these landforms will be impacted by the project.

The remainder of the LAU comprises flat or gently undulating sandplain areas within the Fraser, Wanganut and Yeeda Land Systems, which will be impacted by the project. The geomorphology of all three of these land systems is described as sandplains and dunefields. These land systems are widely represented within the Dampier Peninsula and in the broader Kimberley Region. The Reeves land system, associated with the distinctive hills located in the LAU, is relatively underrepresented in the Kimberley Region and predominantly occurs on the Dampier Peninsula. The area of these land systems contained in the Kimberley Region is as follows (Payne and Schoknecht 2011):

- Yeeda = 21,308 km^2.
- Wanganut = 6,973 km^2.
- Fraser = 728 km^2.
- Reeves = 428 km^2.

Character and Condition of Landforms

The hills of the Reeves land system are characterised as being up to 60 m high, with flat or gently sloping rocky crests up to 800 m wide. They have marginal escarpments up to 70%, locally vertical, and basal scree slopes up to 45% (Payne and Schoknecht 2011). The hills in the LAU generally match this description however some have significantly higher elevations (e.g. Reeves Hill which extends up to 170 mAHD). A slope analysis was not considered to be required given that none of the hills identified in Figure 21 will be impacted by the project (See Section 10.1).

The sandplains and dunefields of the Yeeda, Wanganut and Fraser land systems within the LAU are considered to be representative of those that occur widely on the Dampier Peninsula.

Integrity and Previous Disturbance

From a review of aerial photography and use of DMP's GeoVIEW database, none of the landforms present in the Mine Site Development Envelope appear to have been previously disturbed or fragmented. A small sandstone quarry is located near Dampier Hill, however it is unlikely this has significantly disturbed or fragmented any of the landforms present.

Disturbance to vegetation communities has occurred in the Mine Site Development Envelope from cattle grazing and construction of roads. The nature of these disturbances are considered to have minimal, and only superficial, impacts to the integrity of landforms in that they are unlikely to affect a landform in a permanent or significant way.

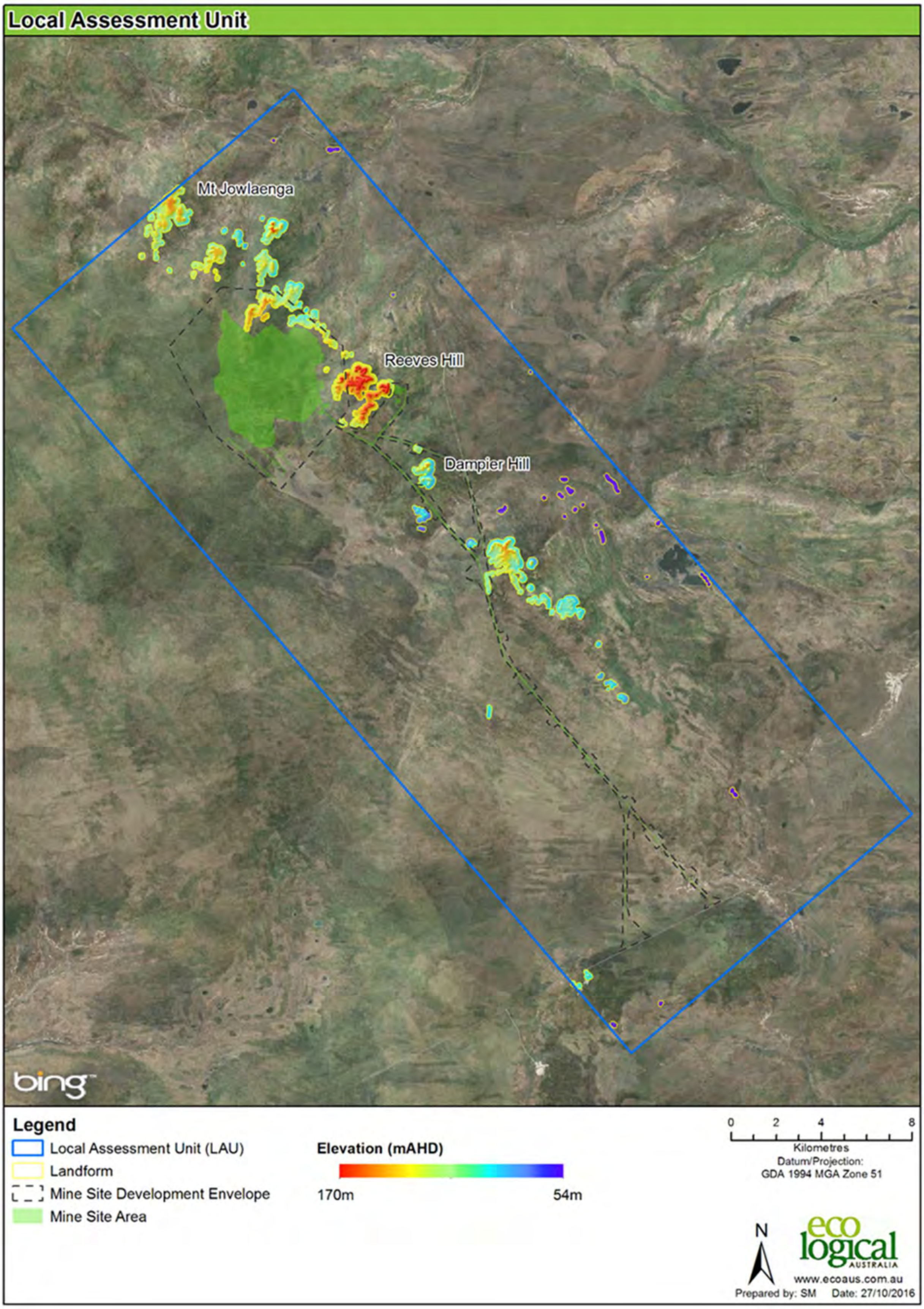

Figure 21: Landform Local Assessment Unit

Ecological Functions

Ecological features of the Mine Site Development Envelope do not appear to be restricted to any one land system.

Scientific or Evolutionary Values

There are no known scientific or evolutionary values associated with the land systems in the Mine Site Development Envelope (Table 18).

Landforms with significant scientific or evolutionary values in WA are identified as geoheritage sites or reserves. A State register of all geoheritage sites and reserves (currently 150 sites and 8 reserves) is managed by the Executive Director of the Geological Survey of Western Australia (GSWA) to assist in managing, preserving and protecting exceptional geological features. Geoheritage focuses on the diversity of minerals, rocks, fossils, and features that indicate the origin and/or alteration of minerals, rocks and fossils. It also includes landforms and other geomorphological features that illustrate the effects of present and past effects of climate and earth forces (McBriar 1995 as cited in Brocx and Semeniuk 2007).

Currently there are no registered geoheritage sites or reserves on the Dampier Peninsula. The closest geoheritage site to the Mine Site Development Envelope is 100 km to the southeast at Gantheaume Point near Broome where dinosaur footprints and other Cretaceous fossils have been recorded along the coast. It is not considered likely that the hills, sandplains or dunefields of the LAU would be considered to be geoheritage sites given they are not unique or restricted to this area and are represented more broadly on the Dampier Peninsula.

4.2.4.3 Regional Soils

The four main soil types (Bettenay *et al*. 1967) within the Land Systems of the region described in Table 18 are:

- Red earthy sands with associated hummocks of siliceous sands.
- Red earthy sands associated with soils on the plains, with dunes and hummocks of red sands. Some soils in lower sites often have a heavy surface layer of ferruginous gravel.
- Neutral red earths and sandy neutral red soils on plains with minor sandstone residuals overlain by extensive rocky outcrops.
- Neutral red earths and red earthy sands within sand plains with irregular dunes/active drainage systems.

4.2.4.4 Local Soils

A baseline assessment of the Mine Site Development Envelope was undertaken through field test pit excavation and laboratory analysis of selected samples (Appendix 6). The assessment examined the soil physical and chemical properties and their suitability for use as cover materials for rehabilitation.

Soils in the Mine Site Development Envelope are dominated by red sands (Pindan) of aeolian origin, which are widespread throughout the Dampier Peninsula. Soil profiles are typically deep (greater than 1 m), although relatively shallow profiles were recorded at several locations where Cretaceous sandstone sedimentary rocks or silcrete hardpan were present within 1 m of the natural soil surface. Minor soil types included deep yellow sand and shallow bleached sand over clay or loam, usually associated with drainage lines or depressions. As such, four soil types were identified within the Mine Site Development Envelope (Table 19):

- Shallow red Pindan sands over sandstone.
- Deep red sandy Pindan soils.
- Yellow sandy soils.
- Bleached Sands Over Clay/Loam.

Table 19: Assessed Soil Type Characteristics

Soil Type	Characteristics
Shallow red Pindan Sands over sandstone	• Uniform fine to medium red sandy soil • Similar to Deep red Pindan sands, but with limited B-horizon due to sandstone less than 1 m from the surface. • Abundant leaf litter. • Absence of gravels (surface and subsoil). • Uniform characteristic red colour, no visible distinction between A and B horizons.
Deep red Pindan Sands	• Uniform fine to medium red sandy soil • Abundant leaf litter. • Absence of gravels (surface and subsoil). • Uniform characteristic red colour, no visible distinction between A- and B- horizons. • At least 1 m deep uniform fine to medium sand B-horizon. • Deeper subsoil may be more yellowish or grey.
Yellow Sands	• Yellow coloured B-horizon and pale surface A-horizon. • Absence of gravels (surface and subsoil). • Limited in extent – restricted to topographical lows.
Bleached Sands Over Clay/Loam	• Shallow distinctively coloured bleached grey loamy sand over a compact grey clay or loam. • Associated with shallow depressions or drainage lines - expected to be prone to seasonal waterlogging. • Abundant termite mounding.

All four soil types displayed uniform physical and chemical properties throughout the depth of their sandy profiles. Laboratory analysis indicated that:

- Soils are non-saline with low sodicity apart from one saline soil collected from a depression with restricted drainage.
- Soils have low cation exchange capacity values, with calcium being the dominant exchangeable cation.
- Soils have low concentrations of organic matter, major plant nutrients, and some minor nutrients.
- Soils have very low concentrations of environmentally significant metals and metalloids.
- Soils exhibit no evidence of uranium enrichment despite the presence of elevated uranium concentrations in ore and mineralised waste materials.
- pH was variable, however the majority (70%) were circum-neutral or slightly alkaline.

Low nutrient availability, coupled with an environment of strong leaching associated with free-draining sandy soils and moderate to high rainfall means that nutrient cycling is critical for sustaining healthy vegetation communities. Woody debris, leaf litter and termite mounds are important repositories of nutrients and organic matter. Frequent fires (Section 4.2.11) and soil biological activity, especially by termites, are essential for efficient nutrient recycling in this environment.

4.2.4.5 Acid Sulfate Soils

The Mine Site Development Envelope is characterised in the ASRIS Acid Sulfate Soil (ASS) mapping as having 'Extremely Low' probability (low confidence) of occurrence within 2 m of the natural soil surface.

Geochemical assessment of mine waste samples for the Mine Site Development Envelope indicate that the majority of waste is Non Acid Forming. Two of the deepest samples assessed were classified as Potentially Acid Forming, and may be reached in the final years of proposed mining. Further detail is provided in Section 8.4.2.

4.2.5 Hydrogeology

Several baseline hydrogeology studies were undertaken for the Mine Site Development Envelope (Pennington Scott 2014; Rockwater 2016) (Appendix 8).

4.2.5.1 Setting

The water table on the Dampier Peninsula is deep inland and becomes progressively shallower on the coastal plain where discharge occurs at coastal springs in the mud flats around Broome. The Baskerville anticline divides groundwater flows, with water flowing northward north of the anticline and south to southwest in areas south of the anticline. The Mine Site Development Envelope is on the southern limb of the anticline where the hydraulic gradient is very low (1.2 x 10^{-3}) and flattens towards the coast (Laws 1991).

4.2.5.2 Broome Sandstone Aquifer

The Broome Sandstone Aquifer is hosted in the Broome Sandstone and the saturated parts of the overlying Emeriau Sandstone and Mowanjum Sand, which are generally in hydraulic continuity. It is a major unconfined to semi-confined aquifer that supplies groundwater to the Broome townsite, rural subdivisions, horticultural areas and pastoral properties. The Jarlemai Siltstone underlies the Broome Sandstone Aquifer and acts as a major aquiclude between it and the Alexander Formation (part of the Wallal Aquifer) below.

Regional Groundwater Levels and Flow

Groundwater levels in the Broome Sandstone Aquifer range from about 75 m AHD near the centre of the Dampier Peninsula to about 0–1 m AHD at the coast (Figure 22). In the northern and eastern parts of the study area, there are regions with sparse groundwater monitoring data and data are most concentrated in the Broome townsite region. The contours (Figure 22) imply that regional groundwater flow is towards the coast under an average hydraulic gradient of 0.00085 (0.85 m per km).

Variations in groundwater levels in monitoring bores for the Broome townsite, although within close proximity to production bores, appear to closely correspond to variations in rainfall. Groundwater levels vary by about 3 m in response to inter-decadal variations in rainfall. This is evident when comparing the cumulative rainfall variation with groundwater levels. The groundwater level trends closely match the trends in cumulative-deviation-from-mean annual rainfall, with an apparent lag of two to three years as observed in other studies (CSIRO 2009; Rockwater 2013, 2014).

Groundwater Levels within the Mine Site Development Envelope

The water table elevation over the mineral deposit area ranges from about 62 m AHD in the south to about 75 m AHD at its northern edge, with groundwater in the Broome Sandstone Aquifer flowing to the south. The hydraulic gradient is steep across the deposit (0.0016; or 1.6 m per km) and decreases to the south (0.0007; or 0.7 m per km) where the upper Broome Sandstone is the main component. Interpreted groundwater level contours are shown in Figure 23. Groundwater levels trends in selected monitoring bores in the mine area appear to closely match the trends in cumulative-deviation-from-mean annual rainfall. The depth to groundwater is in excess of 20 m over most of the area.

Hydraulic Parameters

Test pumping for the HG-series of bores near the Broome town water supply indicates that hydraulic conductivity of the Broome Sandstone Aquifer ranges from 12–23 m/d, averaging 15 m/d (Rockwater 2016). Searle (2012) reports hydraulic conductivities ranging from 2–42 m/d (generally about 15 m/d) over the entire Dampier Peninsula. The Broome Sandstone Aquifer therefore has moderately high hydraulic conductivity, however significant variability occurs.

Results from test pumping of bores within the Mine Site Development Envelope generally agree with reported hydraulic conductivity data for the Broome Sandstone Aquifer sandstone and suggest that the HMS have a comparatively lower hydraulic conductivity value (around 1 m/d) whereas the Broome Sandstone Aquifer basal transitional unit has an intermediate hydraulic conductivity (around 5–10 m/d) (Appendix 8).

4.2.5.3 Recharge

The Broome Sandstone Aquifer is recharged mainly by the direct percolation of rainfall, which falls mostly during summer (Rockwater 2016). Coastal dunes north of Broome are a significant local source of groundwater recharge to the Broome Sandstone Aquifer, which is apparent from the groundwater flow pattern and chemistry (Laws 1991). Recharge rates of 4% to 5% of rainfall were estimated from chloride ratios and flow net interpretations (Laws 1987). This corresponds to groundwater recharge rates of 22 mm to 52 mm from an average annual rainfall of 780 mm/year.

Minor seasonal surface water ponding areas may occur locally in the overlying Pindan sand.

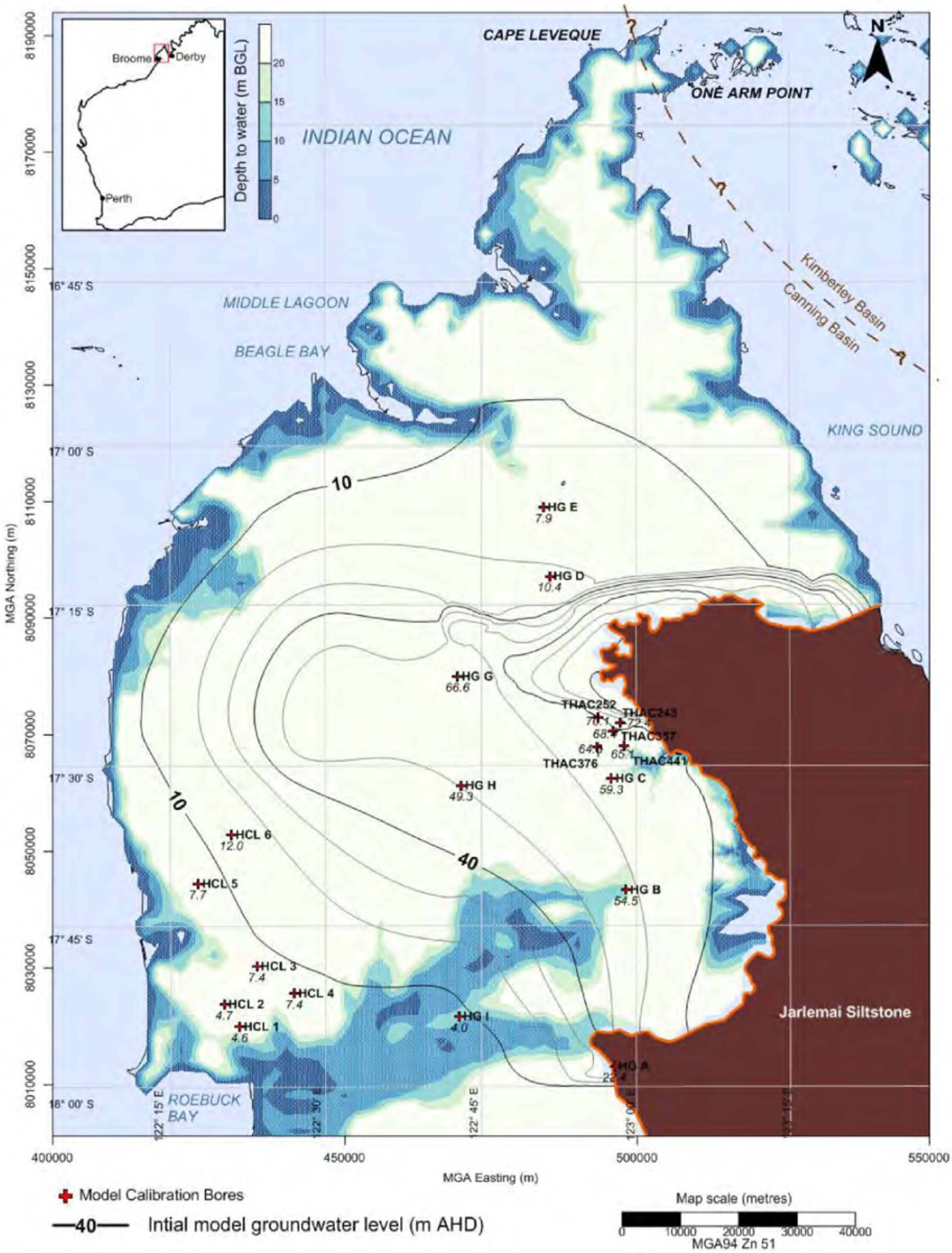

Figure 22: Broome Sandstone Aquifer Groundwater Levels 1997 – 1998

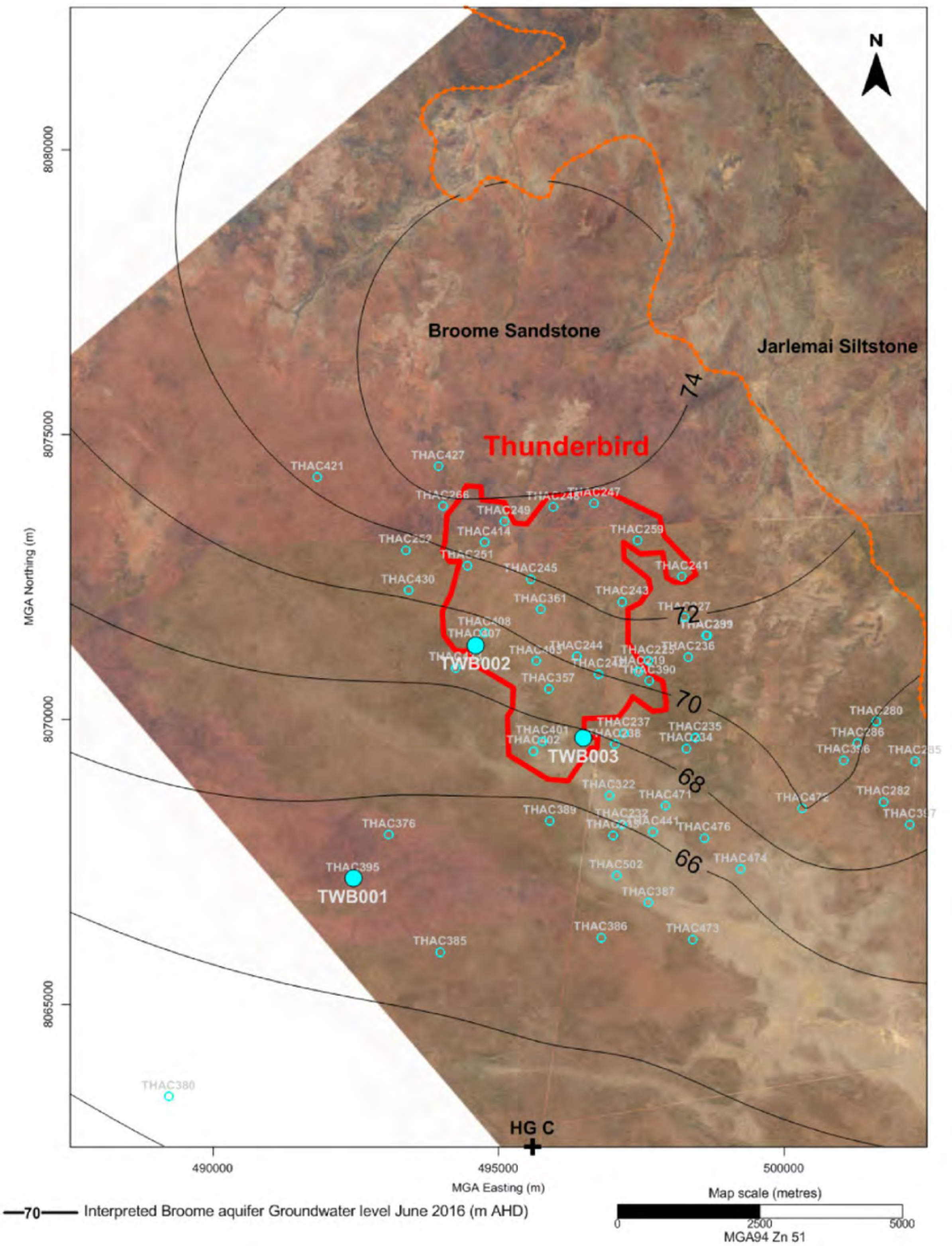

Figure 23: Mine Site Development Envelope Interpreted Groundwater Levels (2016)

4.2.5.4 Groundwater Discharge

Groundwater in the Broome Sandstone Aquifer is discharged to the coast in Gantheaume and Roebuck Bays and to wetlands along Dampier Creek and depressions in the Roebuck and Buckleys Plains (Rockwater 2016). Where there is an upward hydraulic head gradient and a shallow water table, there is a potential for groundwater to discharge upward to the surface environment near the coast. These areas are a significant distance from Mine Site Development Envelope.

No groundwater discharge areas have been identified in the Mine Site Development Envelope.

4.2.5.5 Potential Groundwater Dependant Ecosystems

Groundwater dependent ecosystems (GDEs) are ecosystems that require groundwater in order to maintain their species composition, ecological processes and ecosystem services (SKM 2007). Many ecosystems rely purely on rainfall for their water requirements, but GDEs rely on additional input from groundwater. Changes in the timing, quantity, quality or distribution of groundwater may result in negative impacts on growth and health of vegetation of a GDE and ultimately lead to plant deaths and changes in ecosystem composition (Eamus 2009, Murray *et al.* 2003).

Several areas of vegetation associated with ephemeral waterlogging were noted during early investigations of the project area as potential GDEs, including intermittent ‘soaks’ to the southeast and northeast of the Mine Site Development Envelope (Pennington Scott (2015) in Rockwater (2016)).

The intermittent, ephemeral ‘nearby soak’ occurs about 3 km southeast of the Thunderbird deposit (Plate 4). Rockwater (2016) (Appendix 8) indicates that this area is more likely to be related to seasonal surface water ponding, disconnected from the deeper (approximately 18 m below ground level) Broome Sandstone Aquifer.

An intermittent ‘soak’ occurs over the Jarlemai Siltstone to the northeast in the Fraser River North area. Connection to the deeper Broome Sandstone Aquifer is likely limited in this area due to low hydraulic connectivity with the low-permeability Jarlemai Siltstone (aquitard).

The ephemeral drainage channels in the Fraser River South valleys (Figure 24), about 10.5 km southeast of the mine area, are the only vegetation community which may be supported by groundwater, however, it is also likely that creek line vegetation are sustained by the upper alluvial sands lenses rather than any deeper aquifers. Depths to groundwater range from less than 5 m to more than 20 m (Appendix 8).

Further discussion on the assessment of these vegetation communities as potential GDEs is provided in Section 4.2.8.4.

Plate 4: ‘Soak’ Approximately 3km to the South East of the Mine Site Development Envelope in June 2012

4.2.5.6 Groundwater Quality

The salinity of groundwater in the Broome Sandstone Aquifer is low, but increases near the coastline and Roebuck Plains. Groundwater salinity values of 110 mg/L to 200 mg/L were obtained from the aquifer test boreholes (Pennington Scott 2014).

Groundwater in the Broome Sandstone Aquifer is predominantly of sodium – chloride type, with elevated levels of bicarbonate in some areas (Laws 1991). Silica levels are high, with reported values of 18 to 119 mg/L. Nitrate levels are frequently over 40 mg/L, probably as a result of nitrate fixation by native acacias and termite activity.

A saltwater interface occurs within the Broome Sandstone aquifer along the coastline. The Department of Water areal electromagnetic survey (AEM) indicates it is typically situated about 3 km inland, but can also extend much further inland beneath the Roebuck Plains. Areas of saltwater intrusion and tidal inundation tend to have elevated magnesium and sulphate (Laws 1991).

4.2.5.7 Other Groundwater Users

The main groundwater users for the Broome Sandstone Aquifer are the Water Corporation Broome town water supply borefield, Beagle Bay water supply borefield and isolated pastoral station bores. The closest users to the Mine Site Development Envelope are water bores located at the abandoned Mt Jowlaenga homestead, at the Bedanburu Aboriginal Community and the recently developed Yeeda Abbatoir (Figure 24).

The project is located in the Canning–Pender sub-area of the Canning-Kimberley Groundwater Area, which encompasses the majority of the Dampier Peninsula except for the area near Broome which classified as the Broome Groundwater Area (Figure 24). This area has 95.4% of its available groundwater resources (50 GL/yr) available for allocation. Licence entitlements within the sub-area total 2.3 GL/yr, with one major user (Kilto Station, 2 GL/yr) located about 40 km southwest of the project.

Water Corporation Broome Borefield

The Water Corporation operated Broome borefield is located about 12 km northeast of Broome. It was commissioned in the 1960s and initially consisted of three production bores extracting about 0.4 GL/yr. Borefield extraction has increased as the population of Broome has expanded and the borefield now consists of about 20 production bores extracting about 5 GL/yr. The Water Corporation's current groundwater licence allocation is 6.2 GL/yr. The borefield also contains six monitoring bores that are regularly monitored to provide aquifer response data for borefield operation. A Priority 1 Drinking Water Protection Zone extends north and east from the borefield in the Town Water Reserve (Figure 24).

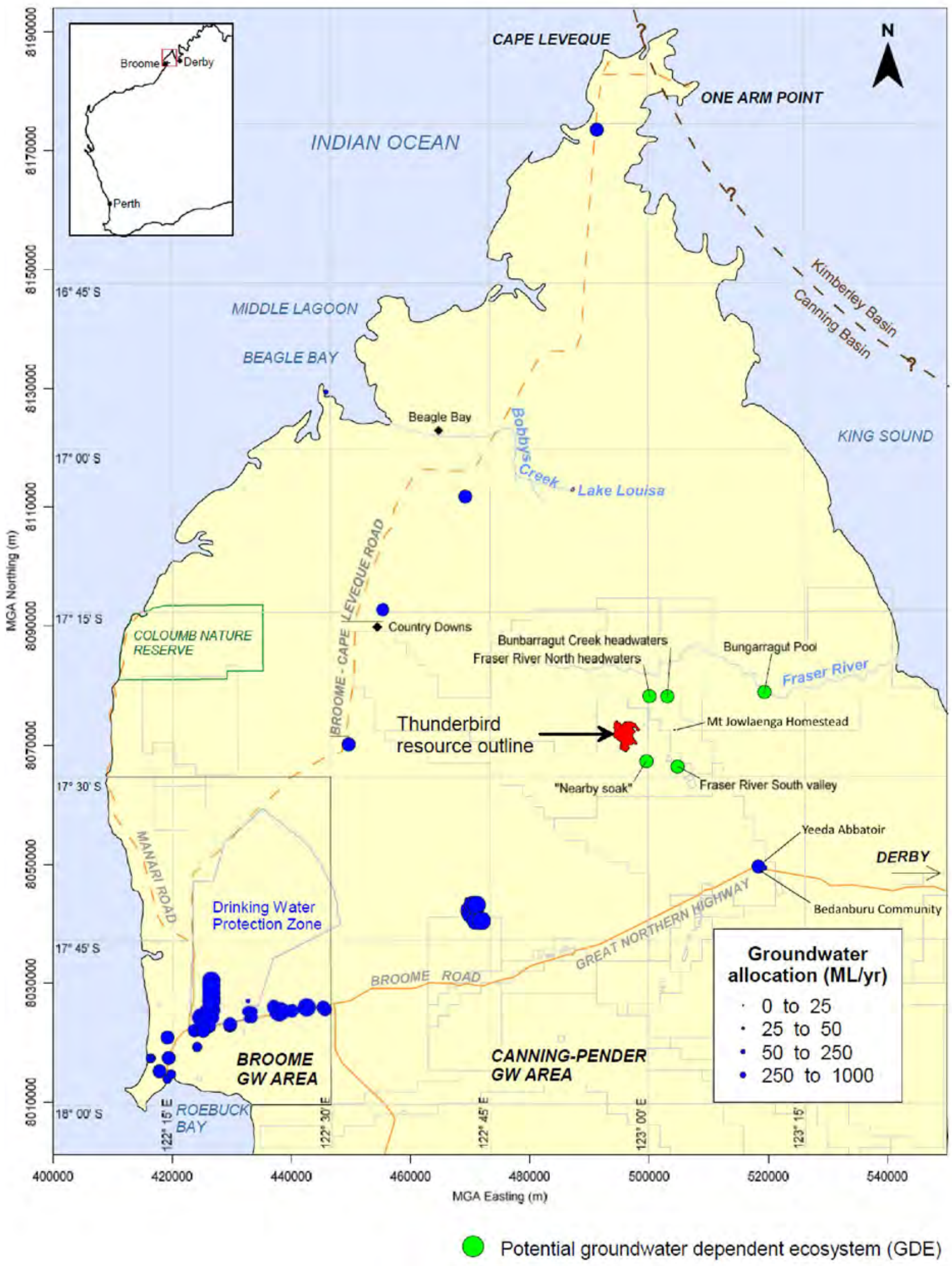

Figure 24: Location of Other Groundwater Users

4.2.6 Hydrology

A Baseline Surface Hydrology Study was undertaken for the Mine Site Development Envelope (MBS 2016a; Appendix 5). The Mine Site Development Envelope is located on sandy soils with low runoff generation and there are no defined watercourses within the main mine development areas. The nearest watercourse is the Fraser River South. Plate 5 shows the Fraser River South Channel near the Site Access Road crossing, approximately 10.5 km downstream from the mineral deposit area. There are no year-round surface water bodies within the Mine Development Envelope. The nearest ephemeral pools are approximately 25 km downstream on Fraser River South.

Plate 5: Fraser River South Near Access Road Crossing

4.2.6.1 Regional Catchments

The Mine Site Development Envelope is within the National Catchments Boundaries Level 2 Cape Leveque Coast River Region of the Level 1 Tanami-Timor Sea Coast Division (Stein *et al*. 2011). The Cape Leveque Coast River Region consists of several river systems draining to the coast and extending approximately 100 km inland.

The Mine Site Development Envelope lies within the catchments of Fraser River, Fraser River South and Little Logue River (Figure 25). While the Fraser River enters King Sound from the west, Little Logue River discharges via Logue River to King Sound at Jarrananga Plain immediately adjacent to the Fitzroy River. The adjacent Fitzroy River Basin is a much larger river basin extending approximately 500 km inland and representing the primary surface water inflow to King Sound.

The majority of project infrastructure is to be located within the Fraser River South catchment (Figure 26). The only infrastructure proposed to be located in the Fraser River Catchment is the accommodation village, though some margins of the mineral deposit area extend approximately 300 m into that catchment. The Little Logue River catchment is crossed by the Site Access Road corridor and does not contain any other project infrastructure besides the Site Access Road and groundwater reinjection infrastructure.

4.2.6.2 Local Catchments

Local catchments of the Mine Site Development Envelope are shown in Figure 26. The catchments of the plant, initial Tailings Storage Facility, and Village have small rocky hills at their heads, and are very small at less than 3 km^2. Defined watercourse channels do not extend far past the base of the hills, but wet ground conditions further down the catchment have been observed following intense rainfall events.

The southern portion of the mineral deposit area has a larger catchment of 108 km^2 extending 17 km upstream referred to as the Deposit South Catchment. There is no distinct watercourse channel associated with the drainage line, but there is a broad valley approximately 450 m wide exhibiting variation in vegetation associated with surface water or shallow groundwater.

The Site Access Road crosses four larger catchments (referred to as R1 to R4) that correspond to each of the drainage lines in the southern portion of the Mine Site Development Envelope:

- R1 (Fraser River South) is by far the largest catchment, and includes the mineral deposit area in its upper reaches. A small defined watercourse channel is visible within a broader flood plain at the road crossing point (Plate 5).
- R2 and R3 are much smaller. R2 is very flat with no visible watercourse within the Mine Site Development Envelope while R3 is steeper and has a distinct water course channel.
- R4 includes both visible sandy drainage channels of the Little Logue River in the lower 2 km and broad valleys with no visible watercourse upstream of this.

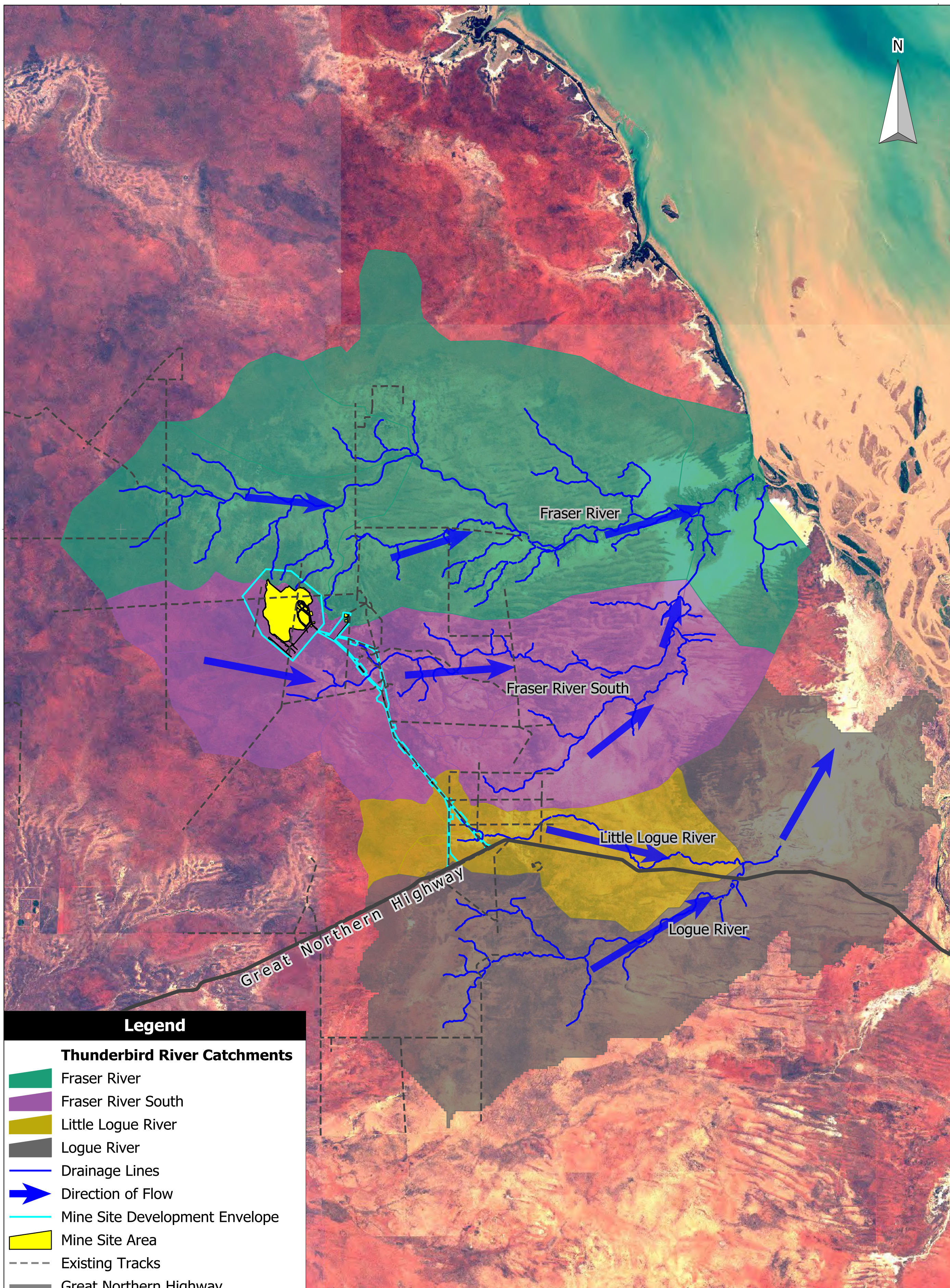

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Image: Copernicus Sentinel Data 2016
Grid: Australia MGA94 (51)
0 10 km

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Thunderbird Mineral Sands Project

Figure 25

Regional Catchment Boundaries

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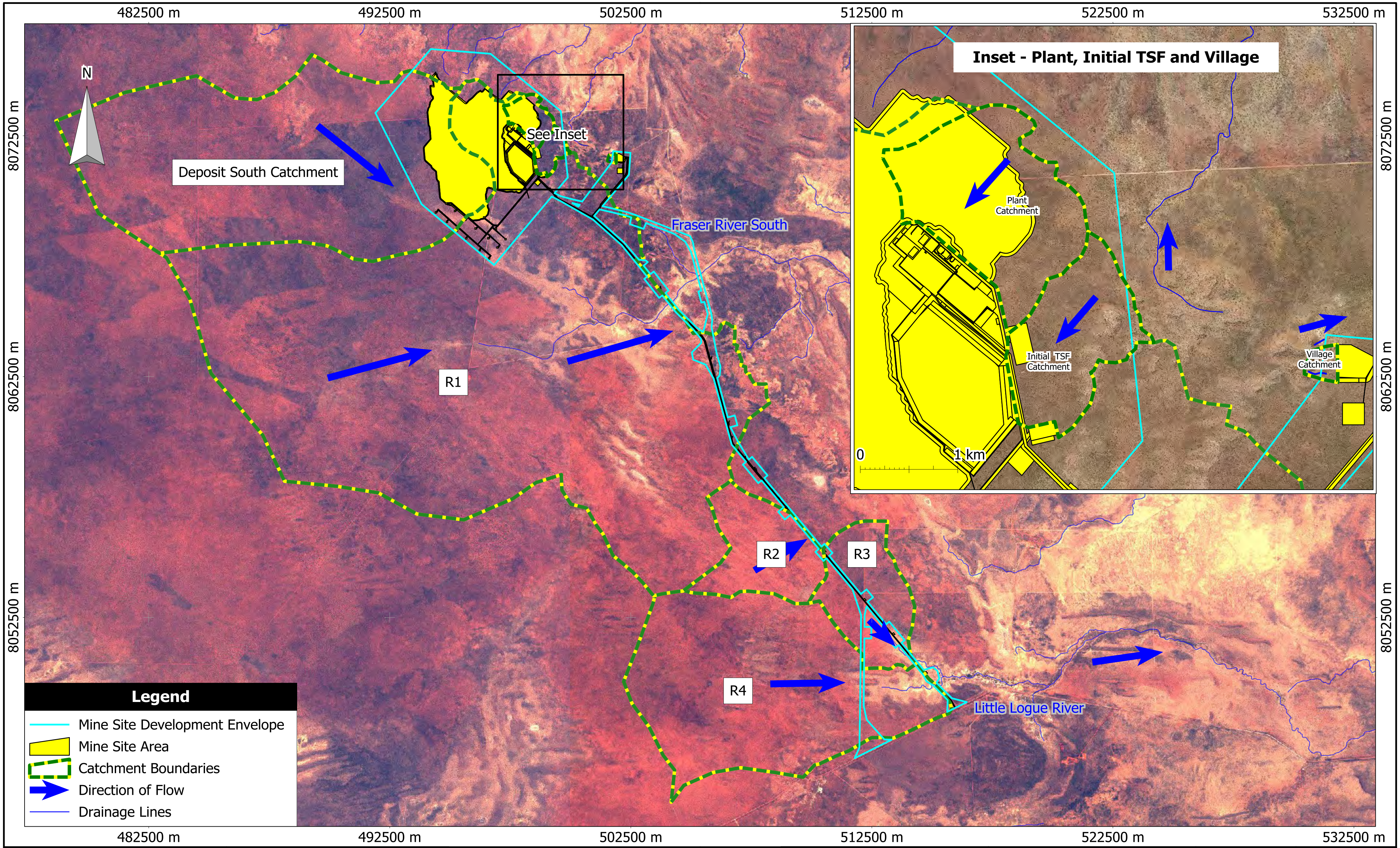

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Image: Copernicus Sentinel Data 2016
Grid: Australia MGA94 (51)

0 5 km

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Figure 26

Mine Site Development Envelope Local Catchments

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4.2.6.3 Runoff Coefficients and Catchment Yield

The sandy soils within the Mine Site Development Envelope are considered to have very high infiltration rates (high hydraulic conductivity of over 200 mm/hr) and therefore low runoff rates (Appendix 5). The small hills with sandstone outcrops will have less hydraulic conductivity, but make up a very small proportion of the catchment area. CSIRO modelling indicates that the average annual runoff coefficients for the Dampier Peninsula are the lowest (0.00 to 0.07) for the entire Northern Australia region (Petheram *et al*. 2009). Runoff coefficients over the remainder of the Fitzroy region, where better calibration data was available, varied from 0.08 to 0.25. The runoff coefficients discussed above are annual averages useful for estimating long term yield of the catchments. Substantially higher coefficients are possible for short periods during individual rainfall events, but runoff rates will still be low relative to other parts of northern Australia.

4.2.6.4 Surface Water Quality

No surface water quality monitoring data is available for the Mine Site Development Envelope or elsewhere on the Dampier Peninsula. Given the lack of industry and other sources of potential contamination, surface runoff is expected to be of good quality suitable for livestock and agricultural use.

All watercourses in the Mine Site Development Envelope remain dry during the dry season. Some salinity records are available from the Fitzroy River, where wet season river flows representing surface runoff quality are typically less than 250 mg/L and often less than 100 mg/L (Lindsay and Commander 2005).

The nearest water quality information available on the Statewide River Water Quality Assessment dataset (DoW 2016) is for the Isdell River (Site 804001), 266 km east of the Mine Site Development Envelope, which had a median total dissolved solids concentration of 106 mg/L and median pH of 7.97 for the period 2005 to 2007.

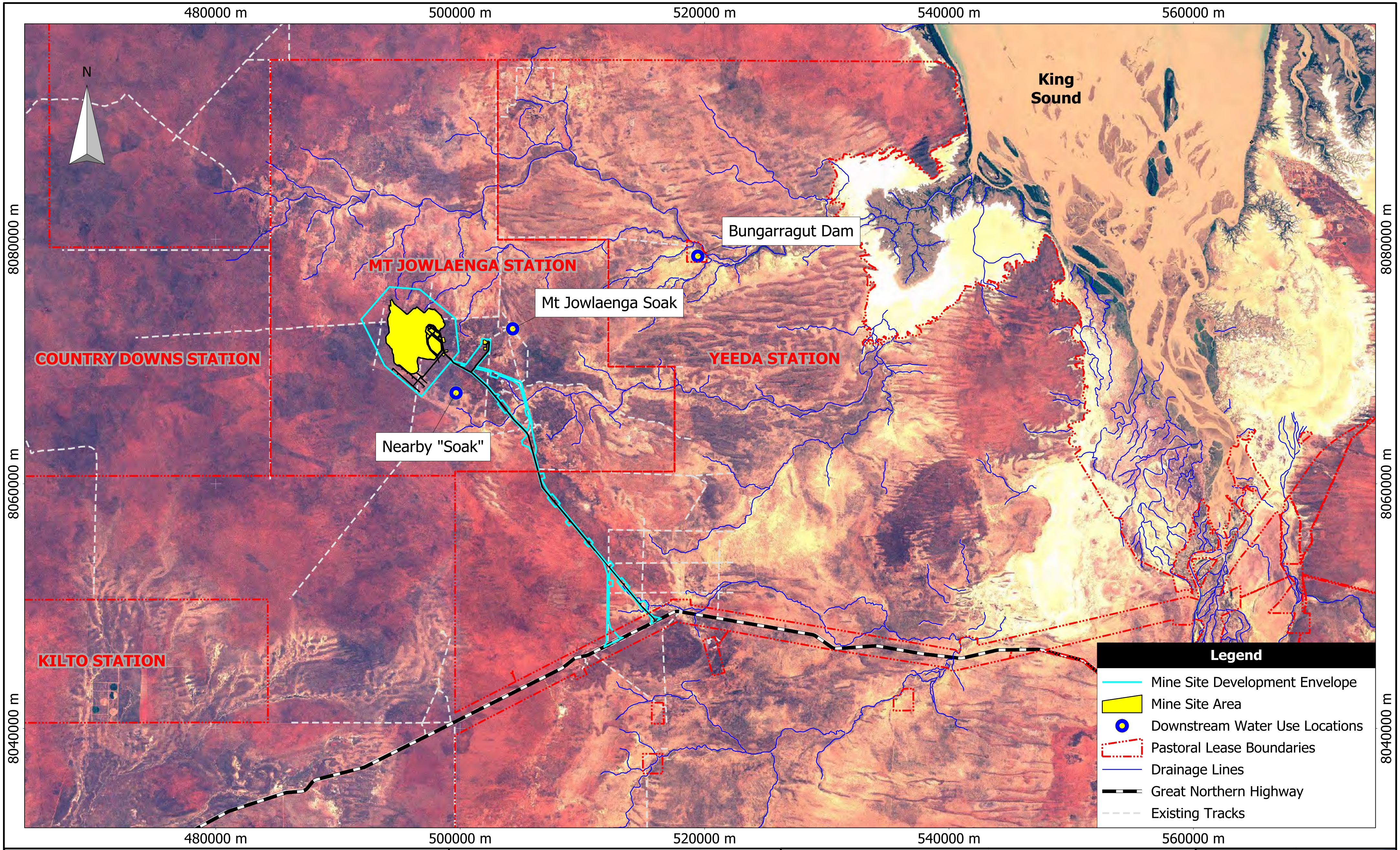
4.2.6.5 Downstream Water Uses

There are no declared surface water areas (*Rights in Water and Irrigation Act 1914*) in either the Mine Site Development Envelope or the Logue and Fraser River catchments. The nearest Public Drinking Water Source Area reserves are near Broome and Derby, well outside the project catchments. The same is true for the Fitzroy River and Tributaries Irrigation area. The Mine Site Development Envelope is located within the Canning-Kimberley Groundwater Area.

Local surface water use is primarily in support of environmental values and some pastoral use. Livestock and domestic water use is not required to be licensed meaning there is no quantitative data on current water use. Figure 27 shows the most significant water use locations identified downstream of the Mine Site Development Envelope. A minor surface expression of groundwater referred to as a 'soak' has been identified approximately 3 km southeast of the proposed mineral deposit area. As part of their agreement with local indigenous people, Sheffield currently maintains a 2 km buffer around this 'soak' which is left undisturbed. It is located off the main watercourses leading from the Mine Site and will not receive surface runoff from the Mine Site Development Envelope.

As shown in Figure 27, the Mine Site Development Envelope and locations 15 to 20 km downstream are within Mt Jowlaenga Pastoral Station. Downstream of this is Yeeda Station which extends to the edge of the King Sound mud flats. Livestock on both stations are likely to utilise surface water for drinking when available.

There is little formal extraction of surface water for pastoral use. There is a natural depression (ephemeral soak) approximately 2 km downstream of the proposed accommodation village which normally contains some water year round, although water levels are augmented from a bore at the nearby unoccupied Mt Jowlaenga Homestead towards the end of each dry season. Historically water was pumped using pipes from this area for station and livestock use; since the station was abandoned the cattle have direct access to the area. Bungarragut Dam is an off-stream water storage facility for livestock water, located near Bungarragut Creek 24 km from the Mine Site Development Envelope and not directly affected by runoff from the Mine Site Development Envelope.



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Original Size: A4
Image: Copernicus Sentinel Data 2016
Grid: Australia MGA94 (51)

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Thunderbird Mineral Sands Project

Figure 27

Downstream Water Use Locations

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4.2.7 Mine Waste Characterisation

A description of the general mine design describing stripping and removal of topsoil, removal of any overburden present and progressive filling of the mine void and replacement of topsoil was provided in Section 3.3.2. A geochemical assessment was made on 57 selected samples from 16 drill holes (Appendix 19) which were considered representative of the materials comprising overburden and mine waste over the life of the project. The samples comprised overburden (13), mineralised waste above the orebody (15), Thunderbird Formation orebody sands (12), mineralised waste below the orebody (14) and basement/marker bed samples (3). The latter two materials are below the limit of excavation, but may be disturbed to some degree by mining operations.

A description of the ore processing and types of waste generate from processing of the mineral sands ore was provided in Section 3.4. A geochemical assessment was made on four samples of process residues (MSP Rejects, combined CUP MSP tails, WCP tails and gypsum acid neutralisation residue - refer Table 8) as well as two samples of oversize material from MUP screening (>2 mm and > 5 mm size fractions was made and provided in (Appendix 20).

A summary of the results of the assessments for overburden, mine waste and residues is provided below.

4.2.7.1 Overburden

Most overburden material from the project consists of highly leached and weathered Pindan sands located above the watertable with properties matching that of subsoils taken in the soil and landform survey within the Mine Site Development Envelope (Appendix 6). This material was found to be:

- Circum-neutral to slightly acidic in pH with a range of pH values from 5.5 to 6.7 with very low levels of soluble salts and essentially no soluble alkalinity.
- All 13 samples of overburden assessed had essentially no sulfur or sulfides capable of oxidation to generate acidic conditions (maximum 0.01% S). The samples were deemed to be 'barren', having no acid forming nor acid neutralising capacity.
- Overburden samples did not contain any metals or metalloids considered enriched versus global crustal averages, and concentrations of all environmentally significant metals and metalloids tested were low to very low indicating a very low risk to the environment.
- Concentrations of water soluble elements of environmental significance in mine waste samples were generally very low to non-detectable and below ANZECC livestock drinking water guidelines for all samples indicating there is an extremely low risk of mine waste leachates from circum-neutral mine waters adversely impacting the surrounding environment by rainfall or groundwater interaction.
- Exposure of overburden to conditions of dilute acid leaching confirmed negligible levels of calcium and magnesium carbonates were available for buffering capacity/acid neutralisation. Low levels of aluminium and iron were the primary elements solubilised, which is consistent with a natural presence of hydrated aluminium and iron oxides from weathering and groundwater interactions. Concentrations of all other environmentally significant metals and metalloids were very still very low in all samples under acidic conditions and below corresponding ANZECC livestock drinking water guidelines.
- Particle size analysis indicated all samples had approximately 10% clay content with clay and silt fractions (<20 μm) together combining for approximately 50% by weight of material however cation exchange capacity measurements indicated samples of overburden were non-sodic to marginally sodic with a correspondingly lower risk of dispersion.

Overburden material from the Mine Site Development Envelope is therefore considered extremely benign and highly leached sands from the Pindan formation which are not deemed particularly dispersive and are not considered to pose any risk due to handling to the surrounding environment.

4.2.7.2 Mine Waste

Geochemical assessment of 44 samples of mine waste from below the overburden layer indicated properties which were generally similar to the overlying overburden and key points are outlined as follows:

- Similar to the overburden, the vast majority of samples of mine waste contained very low concentrations of sulfur and acid neutralising capacity and were classified as non-acid forming and ‘barren’. Natural pH values for all but two samples were circum-neutral to slightly acidic (pH 5.1 to 7.2) and very low in soluble salts and soluble alkalinity
- The two deepest samples assessed (SB006113 and SB012707) at or below 53.5 m below the natural water table (approximately 88.5 m below surface) were found to contain 0.22% and 0.96% sulfur respectively and were classified as potentially acid forming and indeed had pH values of 3.1 upon receipt indicating acid generation prior to assessment with elevated salinity resulting from acid sulfate formation. These samples were identified as basement material or mineralised waste below the orebody and are not intended for excavation and this depth of mining will not be encountered until at least 38 years into the project.
- Thorium was the most significantly enriched element associated with orebody samples and mineralised waste samples below the orebody. Thorium concentrations in these samples ranged from 110 to 160 mg/kg (global abundance index of three) versus a crustal average of 10 mg/kg. Thorium enrichment is associated with the naturally elevated concentrations of monazite present in the Thunderbird deposit. Both water and dilute acid leachate testing indicated these total concentrations will not be mobilised under any mining conditions.
- Minor enrichment in selenium in orebody and mineralised waste samples below the orebody was also noted (2.6 to 3.8 mg/kg) versus the average soil concentration of 0.2 mg/kg. Both water and dilute acid leachate testing indicated these total concentrations will not be mobilised under any expected mining conditions.
- Concentrations of all water soluble elements of environmental significance in mine waste samples at circum-neutral pH were very low to non-detectable and below ANZECC livestock drinking (the only current beneficial use of groundwater) water guidelines for all samples tested. Overall, results indicate there is an extremely low risk of mine waste leachates from circum-neutral waters adversely impacting the surrounding environment by rainfall or groundwater interaction.
- Exposure of mine waste samples to conditions of dilute acid leaching indicated low levels of aluminium and iron were the primary elements solubilised. As for overburden samples, the concentrations of all other environmentally significant metals and metalloids were very still very low in all samples under acidic conditions and below corresponding ANZECC livestock drinking water guidelines.
- Cation exchange capacity measurements of mine waste samples were moderately to highly sodic with orebody samples being highest in sodicity (ESP values of 10.9 to 26.8%) and at higher risk of dispersion than overburden material when also combined with the fine particle size of the material. Processing of the ore will use flocculants to control this tendency and other mine waste will be returned to the mine void and not placed on the surface.

Overall, results indicate that mine waste at depths less than 48.5 m below the natural water table (approximately 83.5 m below surface) will be non-acid forming and barren with essentially no capacity for acid generation or acid neutralisation similar to overburden material. Levels of soluble salts, metals and metalloids in any seepage from these materials will be extremely low, even under artificially generated mildly acidic conditions of tests. Between 48.5 m and 53.5 m below the natural water table some potentially acid forming material was encountered and although the potential for leaching of metals under acid conditions was restricted to iron and aluminium, further investigation and management prior to any disturbance will be required. As this material will not be encountered until very late in the life of mine (>35 years) these studies and management plans can be conducted well in advance of any potential disturbance including from mine dewatering.

4.2.7.3 Residues

Geochemical assessment of the four residue samples and two oversize ore streams from metallurgical trials for the project indicated the following:

- All samples were classified as non-acid forming and 'barren', having essentially no acid forming or acid neutralising capacity.
- Natural pH values for samples other than 'gypsum' were marginally acidic (5.7 to 6.5 pH) as for general mine waste, overburden and Pindan sands with essentially no soluble alkalinity. The gypsum residue sample had low levels of residual alkalinity (29 mg/L as $CaCO_3$) and a slightly higher pH (7.6).
- With the exception of the gypsum residue, all samples all had extremely low levels of soluble salts. Gypsum residue was a source of slightly soluble calcium sulfate but comprises a very minor waste stream (0.025% of materials processed).
- As expected for a mineral sand deposit, thorium and uranium were the most commonly enriched elements and considered associated with naturally elevated concentrations of the mineral monazite present in the Thunderbird deposit. Despite enrichment versus global crustal averages, both water and dilute acid leachate testing indicated thorium and uranium will not be mobilised under any expected mining conditions, indicating these naturally enriched elements are present in a highly insoluble and environmentally unavailable form.
- Lead (357 mg/kg) and selenium (4 mg/kg) were also marginally enriched in MSP rejects as a result of mineral separation from the source ore material. Again water and dilute acid leaching indicated this natural enrichment was in an environmentally unavailable form.
- As for overburden and mine waste samples, concentrations of all environmentally significant metals and metalloids in water or dilute acid conditions from residue samples were very low to non-detectable apart from minor concentrations of aluminium under acidic conditions (but still below ANZECC livestock drinking water guidelines in the 1:20 extract). Gypsum had very low concentrations of some metals but remained below ANZECC guidelines and is a very minor waste stream by volume for the project (0.025%). Overall, results indicate there is an extremely low risk of process residue leachates adversely impacting the surrounding environment by rainfall/groundwater/process water interaction.
- Analysis of the gypsum residue indicated the presence of significant unreacted calcium and magnesium carbonates (calcite and dolomite total 51%) in the lime being used for neutralisation of the sulfuric acid leach of the zircon concentrate. The soluble components of the gypsum and underlying calcite and dolomite are expected to gradually dissolve following co-disposal of this minor waste stream in the mine void with other waste by interaction with rainfall/groundwater.
- As for general mine waste, there is a tendency for dispersion/creation of turbid water of fine material in the residues streams other than gypsum. This will be controlled during processing by use of flocculants and placement of the slurry waste into the mine void.

Overall, results indicate that project tailings will be barren with essentially no capacity for acid generation or acid neutralisation. Predicted concentrations of soluble salts, metals and metalloids in any seepage are expected to be extremely low. Low overall (in relation to waste volumes) levels of calcium sulfate and calcium carbonate will gradually be mobilised by leaching from the 'gypsum' residue, however seepage water quality will mostly reflect process groundwater quality as drawn from local aquifers. Although various residues are geochemically enriched in thorium, uranium, lead and selenium, these elements were not found to be mobile, even under artificially applied acidic conditions. All process waste streams are thus considered environmentally benign for the project.

4.2.8 Flora and Vegetation

Five flora and vegetation surveys have been undertaken for the Mine Site Development Envelope and surrounds between 2012 and 2016 (
Table 20). All are provided in Appendix 9.

Table 20: Flora and Vegetation Surveys

Survey	Timing	Methodology
Thunderbird Dampier Peninsula Project Level 1 Flora and Fauna Assessment (Ecologia 2012a).	June 2012	17 quadrats as well as transects.
Thunderbird Project Level 2 Flora and Vegetation Assessment (Ecologia 2014b).	April 2013	71 quadrats, as well as opportunistic collections, releves, and traverses
Thunderbird Haul Road and Accommodation Camp Flora and Fauna Assessment (Ecologia 2015).	May 2015	16 quadrats as well as transects.
Flora and Vegetation of the Thunderbird Mineral Sands Project Area (Mattiske 2016a).	June 2016	155 quadrats, as well as opportunistic collections, releves, and traverses.
Potential Groundwater Dependent Ecosystems in the Thunderbird Mineral Sands Project Area (Mattiske 2016b)	Nov 2016	Aerial imagery assessment and field tree health (

The flora and vegetation surveys were undertaken in accordance with Guidance Statement 51 (EPA 2004c) and the later surveys, also in accordance with the EPA and Department of Parks and Wildlife (DPaW) Technical Guide (2015a). In 2016, Mattiske Consulting conducted a technical peer review of the Ecologia botanical reports (Ecologia 2012a, 2014b and 2015). Following the technical peer review, an additional survey was conducted in June 2016 to address issues and methodological gaps within earlier surveys (Mattiske 2016a). MBS Environmental conducted a gap analysis between items identified within the peer review and the Mattiske (2016a) report to ensure the key issues had been addressed. A copy of the gap analysis is contained in Appendix 9.

An additional survey was conducted in November 2016 to specifically address potential GDE vegetation within the project area.

A total of 255 vascular plant taxa, representative of 129 genera and 44 families were recorded in the survey area (the survey area was larger than the Mine Site Development Envelope) (Mattiske 2016a). The majority of taxa recorded were representative of the Poaceae (46 taxa), Fabaceae (45 taxa), Malvaceae (18 taxa), Cyperaceae (14 taxa), Myrtaceae (14 taxa), Amaranthaceae (12 taxa) and Convolvulaceae (10 taxa) families.

4.2.8.1 Conservation Significant Flora

No Threatened flora pursuant to Schedule 1 of the *Wildlife Conservation Act 1950* or *Environment Protection and Biodiversity Conservation Act 1999* were recorded within the Mine Site Development Envelope by any survey (Ecologia 2012a, 2014b, 2015, Mattiske 2016a).

Two Priority taxa were recorded within the flora survey area by Mattiske (2016a) and Ecologia (2012a, 2014b, 2015a), *Triodia caelestialis* (P3) and *Pterocaulon intermedium* (P3) (Mattiske 2016a) (Table 21 and Figure 28). *Triodia caelestialis* was recorded widely, with *Pterocaulon intermedium* (P3) recorded infrequently. Neither taxon was associated with any specific landforms, soil types or vegetation communities.

Three other Priority flora taxa were recorded infrequently in the survey area by Ecologia (2012a, 2014b, 2015) (Table 21 and Figure 28). These taxa were *Fuirena incrassata* (P3), *Fuirena nudiflora* (P1), and *Tephrosia valleculata* (P3). *Eriachne* sp. *Dampier Peninsula* (K.F. Kenneally 5946) was previously reported as a Priority 3 (Ecologia 2014b), however, is no longer listed as a priority taxon (DPaW 2016b). None of these three taxa were recorded during the Mattiske (2016a) survey of the Mine Site Development Envelope.

Poor rainfall conditions prior to the 2016 survey may have precluded *Fuirena incrassata* (P3), an annual species, from being recorded. However, according to DPaW (2016b), the distribution of *Fuirena nudiflora* (P1) is restricted to the Victoria Bonaparte and Central Range IBRA regions, near to the borders of the Northern Territory and South Australia. Its presence in the Mine Site Development Envelope survey area would represent a range extension of approximately 1,000 km to the west (DPaW 2016b). No specialist taxonomic identification was undertaken in 2014 to confirm its presence within the Mine Site Development Envelope survey area.

Tephrosia valleculata (P3) is known to occur within approximately 200 km of the Thunderbird Project Area (DPaW 2016b) on rock outcrops and soil around sandstone (DPaW 2016b). Due to poor seasonal conditions or possible opportunistic occurrence of the taxon, it was not recorded during the 2016 survey. It cannot be certain that the taxon was present as no specialist taxonomic identification was undertaken in 2014. Notwithstanding, given its preference for rocky outcrops (DPaW 2016b), it is unlikely to be impacted by Project development within the Mine Site Development Envelope (Mattiske 2016a).

Table 21: Priority Flora Taxa Recorded Within Mine Site Development Envelope

Species	Conservation Listing	Within Development Envelope
Pterocaulon intermedium	P3	Yes by Mattiske and Ecologia
Triodia caelestialis	P3	Yes by Mattiske
Tephrosia valleculata	P3	Yes by Ecologia
Fuirena incrassata	P3	No
Fuirena nudiflora	P1	No

One taxon, *Aristida contorta,* had an approximately 300 km range extension from known records to either the east or southwest of the survey area (DPaW 2016b). This taxon is not considered to be of conservation significance as it is a common grass widely distributed throughout the state. Ecologia (2014b) reported 26 taxa that represented range extensions of more than 100 km from their then known range. All range extensions are likely to be associated with the low level of survey of the less accessible areas of the Dampier Peninsula (Mattiske 2016a).

Another species of interest is *Tephrosia* aff. *crocea*. This species was recorded across the survey area and not restricted to a unique landform, but predominantly collected on the red sandy soils containing Pindan vegetation on the flats. This species could not be fully identified due to only sterile specimens being collected. Should this species be observed in flower or fruit, specimens should be collected to permit an accurate identification.

4.2.8.2 Vegetation Communities

A total of 15 vegetation communities were defined and mapped, based on a statistical analysis of the combined data from Ecologia (2012a, 2014b and 2015) and Mattiske (2016a) (Figure 28).

Two of the pindan vegetation communities (low sparse eucalypt woodlands over *Acacia tumida* shrubland over *Triodia/Chrysopogon* grasslands), W6 and W8, accounted for approximately 86% of the surveyed area and were considered the most representative of the Mine Site Development Envelope (Mattiske 2016a).

The other main communities mapped were associated with the drainage channels (*Melaleuca viridiflora/Melaleuca alsophila* woodland) and rocky hills. Vegetation associated with the hills and drainage channels within the Mine Site Development Envelope were statistically different from the vegetation communities defined on the flats.

In broad terms, the vegetation of the Mine Site Development Envelope consists of vegetation with a sparse overstorey of *Eucalyptus/Corymbia* species – typically *Corymbia greeniana/Eucalyptus tectifica* – over a mid-storey of *Acacia* species, dominated by *Acacia tumida* var. tumida, and a ground cover of mixed grasses, with *Triodia caelestialis* (P3), *Triodia schinzii,* and *Chrysopogon species* (*C. pallidus, C. timorense*) being dominant. Other common species in the upper storey included *Brachychiton diversifolius Corymbia zygophylla, Erythrophleum chlorostachys*, and *Eucalyptus flavescens. Atalaya hemiglauca, Bauhinia cunninghamii,* *Dolichandrone heterophylla, Ehretia saligna, Gardenia pyriformis* subsp. *keartlandii, Grevillea pyramidalis, Hakea arborescens,* and *Hakea macrocarpa* were common midstorey species. Some of these, such as *Bauhinia cunninghamii*, were often of sufficient size as to form a component of the upper storey. The vegetation is essentially Pindan and is common and widespread through the broader Kimberley region.

Overall, the vegetation communities mapped and species recorded in the wider area surrounding and including the Mine Site Development Envelope are consistent with the historical mapping of Beard (1976) and the more recent land systems mapping of Kimberley by Schoknecht and Payne (2010).

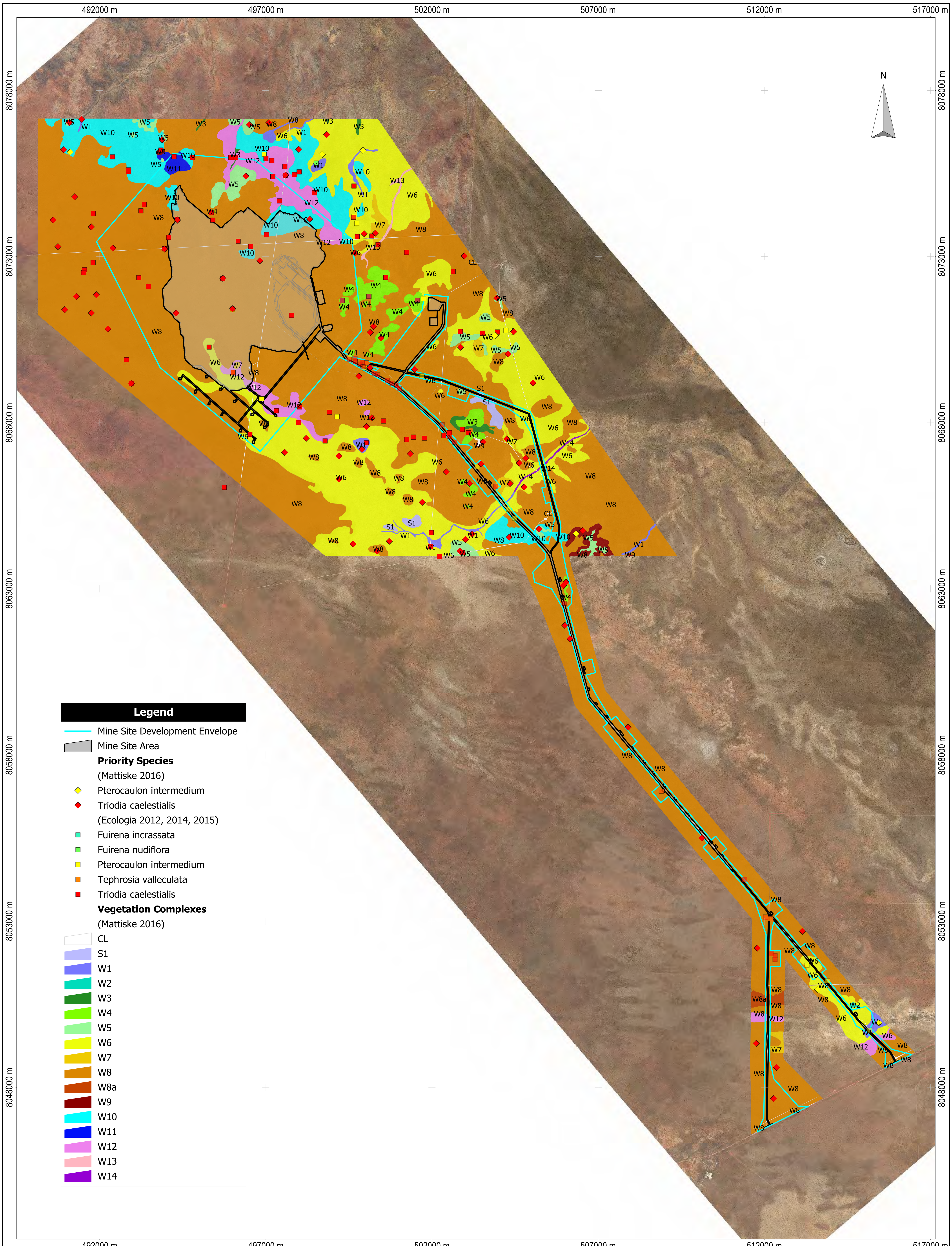

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Figure 28

Vegetation Communities and Conservation Significant Flora within the Minesite Development Envelope Survey Area

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4.2.8.3 Threatened and Priority Ecological Communities

No Threatened Ecological Communities (TECs), pursuant to Schedule 1 of the *WC Act* or *EPBC Act* occur within 50 km of the Mine Site Development Envelope.

No Priority Ecological Communities (PECs) as listed by DPaW (2016c) currently intersect the Mine Site Development Envelope. There are currently three Priority 1 and five Priority 3 PECs, as listed by DPaW (2016c, DPaW Reference 01-0816EC), which occur within 50 km of the Mine Site Development Envelope.

A 14.5 ha drainage channel community consisting of *Melaleuca viridiflora*/*Melaleuca alsophila* (statistically groups with community W1) within the Mine Site Development Envelope was claimed by Ecologia (2014b) to have some resemblance to the Lolly Wells Spring wetland complex Priority 3 PEC assemblage. The Lolly Wells Spring assemblage is groundwater dependant, as it is likely to exist in areas of permanent fresh water, such as areas with numerous low organic mound springs with moats. The assemblage supports groves of *Melaleuca cajuputi* and *Melaleuca viridiflora*, together with aquatic species such as *Nymphaea violacea*, *Nymphoides indica* and *Nymphoides beaglensis.*

The survey area does not contain areas of vegetation consistent with permanent water associated with springs (Mattiske 2016a). The claim that community W1 was similar to the Lolly Wells Spring assemblage was not supported by any statistical analysis or reasonable argument. Mattiske (2016a) reported that the potential PEC area is set in a low lying area amongst gentle slopes and receives internal surface water drainage (Appendix 9).

4.2.8.4 Potential Groundwater Dependent Ecosystems

Pennington Scott (2015) inferred potential GDEs within the project area and wider region as reported in Rockwater (2016). These are described in Section 4.2.5.5.

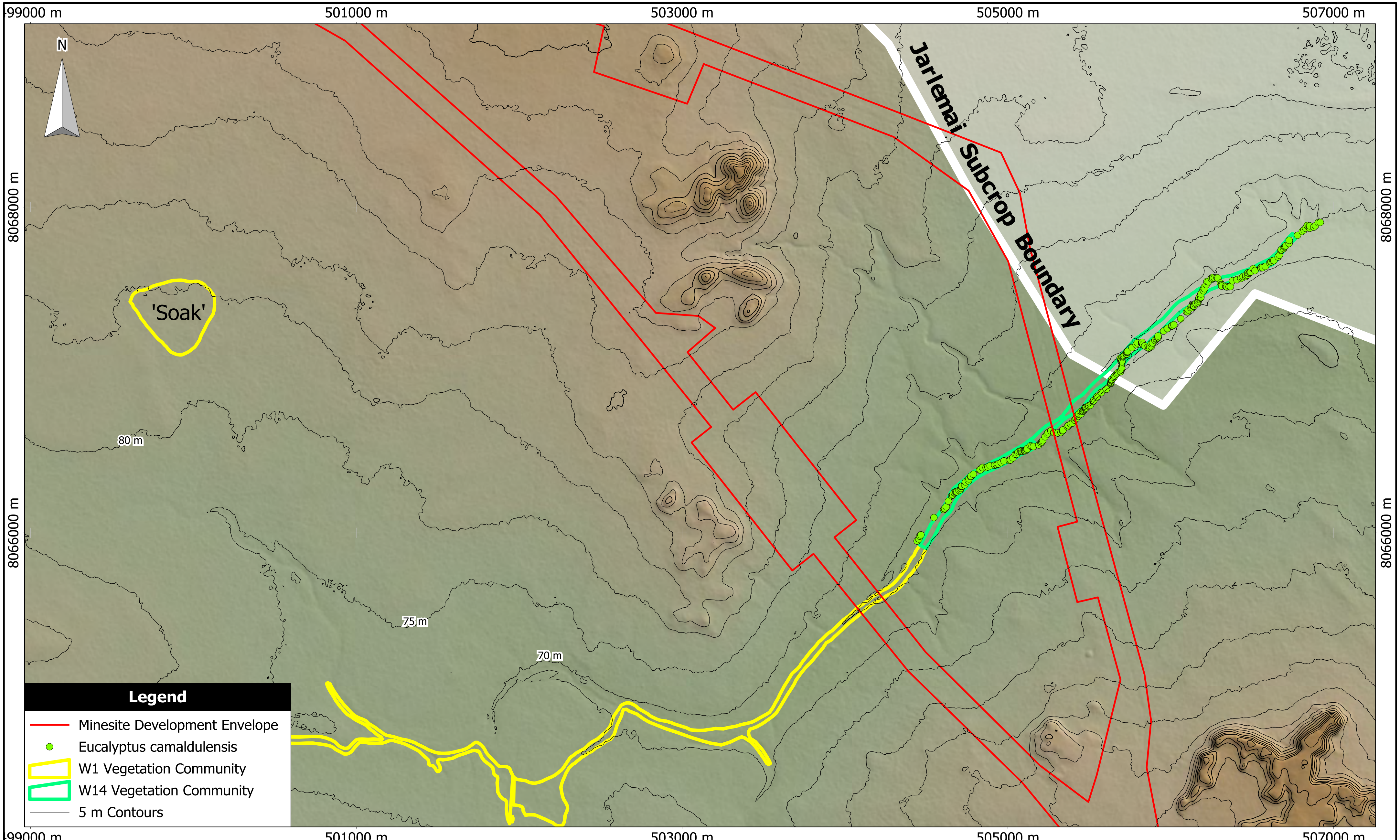
Ecologia (2014b) also indicated the potential presence of a PEC that may be groundwater dependent. This potential PEC correlates to the "nearby soak" as identified by Pennington Scott (2015). However, the potential PEC was not supported by Mattiske (2016a) (see Section 4.2.8.3). Additional observation of the soak at the end of the 2016 dry season showed the dominant species *Melaleuca alsophila* and *Melaleuca viridiflora* as severely water restricted and consequently in a very stressed condition, indicating that they do not have access to groundwater (Mattiske 2016b). Additionally, Rockwater 2016 suggested that the area is likely to be a perched aquifer not connected to the deeper Broome Sandstone Aquifer (Rockwater 2016).

Pennington Scott (2015) as reported in Rockwater (2016) also identified the ephemeral drainage line of the Fraser River South valleys as a potential GDE. The 3 km eastern section of the Fraser River South was classified as the W14 community (Figure 29), defined as "*Eucalyptus camaldulensis* mid open woodland over *Melaleuca viridiflora, Melaleuca alsophila* and *Bauhinia cunninghamii* mid sparse shrubland over *Ectrosia schultzii, Eriachne sulcata* and *Fimbristylis littoralis* low sparse grassland on grey to light brown sandy clay soils in drainage channels" (Mattiske 2016a). This community was the only location where *Eucalyptus camaldulensis* was recorded, however it occurs widely outside of the project area, across most of the Australian mainland (Chippendale 1988, DPaW 2016b). *Eucalyptus camaldulensis* is considered to be facultatively dependant on groundwater, in that its root structure allows it to access water at different depths in the soil profile depending on the availability of water in different seasons and conditions (Mattiske 2016b).

The November 2016 GDE survey (Mattiske 2016b; Appendix 9) assessed species for their groundwater dependence. The W14 community was the only community considered to groundwater dependent. *Eucalyptus camaldulensis* were sparsely scattered along the drainage channel from their first recorded occurrence, with trees becoming more frequent in number and more evenly distributed further east along the drainage channel and its banks (Figure 29). The distribution of *Eucalyptus camaldulensis* along Fraser River South conforms with the interpolated shallow depth to groundwater (as presented in Rockwater 2016; Appendix 8). However, the source of plant available groundwater is still undetermined as it is possible that vegetation is sustained by upper alluvial sands lenses, rather than any deeper aquifers.

4.2.8.5 Introduced Flora

A total of 11 introduced (exotic) plant taxa have been recorded within the wider survey area by Ecologia (2012, 2014b) and Mattiske (2016). These include **Cyanthillium cinereum, *Cynodon dactylon, *Digitaria ciliaris, *Echinochloa colona, *Sida acuta, *Stylosanthes hamata, *Stylosanthes scabra, *Tridax procumbens, *Cenchrus ciliaris, *Portulaca pilosa* and **Stylosanthes humilis.* **Sida acuta*, a Declared Pest common to the Kimberley, was recorded by Ecologia (2014b). However this weed was recorded outside the Mine Site Development Envelope.



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Satellite Image: Copernicus Sentinel Data 2016
Grid: Australia MGA94 (51)

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Figure 29

Distribution of *Eucalyptus camaldulensis* along Fraser River South

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W:\Sheffield Resources\PER\Drawings\PER Map.map 21/12/2016 F29 GDE location Layout

4.2.9 Terrestrial Fauna and Habitats

A total of four fauna assessments have been undertaken for the Mine Site Development Envelope and surrounding areas between 2012 and 2016 (Appendix 9), including:

- Level 1 Flora and Fauna Assessment (Ecologia 2012a).
- Level 2 Terrestrial and Subterranean Fauna Assessment (Ecologia 2014a).
- Haul Road and Accommodation Village Flora and Fauna Assessment (Ecologia 2015).
- Targeted Greater Bilby Assessment (Ecologia 2016).

These surveys covered an area of approximately 14,891 ha compared to the Mine Site Development Envelope of 5,875 ha. The surveys all included detailed literature reviews that informed the survey methodology and guided the studies. This included but was not limited to:

- A review of background information (including literature and database searches).
- An inventory of fauna species observed at the study area.
- An inventory and a map of species of biological and conservation significance recorded or likely to occur within the study area and surrounds;
- An inventory of fauna species occurring at the study area incorporating recent published and unpublished records.
- A map and detailed description of fauna habitats at the study area.
- An appraisal of the current knowledge base for the area, including a review of previous surveys conducted in the area relevant to the current study.
- A review of regional and biogeographical significance, including the conservation status of species recorded at the study area.

Each survey was undertaken in accordance with the following:

- Section 4a of the EP Act.
- EPA Position Statement No. 3, Terrestrial Biological Surveys as an Element of Biodiversity Protection (EPA 2002).
- EPA Guidance Statement No. 56, Terrestrial Fauna Surveys for Environmental Impact Assessment (EPA 2004d).
- EPA and DEC Technical Guide – Terrestrial Vertebrate Fauna Surveys for Environmental Impact Assessment (EPA and DEC 2010).
- Survey Guidelines for Australia's Threatened Mammals (DSEWPC 2011).

In addition a technical peer review of the fauna surveys undertaken for the project was completed by Western Wildlife and is attached as Appendix 10. The peer review concluded that the surveys were generally consistent with relevant State and Commonwealth guidelines, and that vertebrate fauna surveys were completed at an appropriate level and to a generally high standard. The peer review did not recommend any further actions.

4.2.9.1 Fauna Habitats

Three broad fauna habitats were identified within the Mine Site Development Envelope (Ecologia 2012a, 2014a, 2015):

- Pindan Shrubland.
- Savannah Woodland.
- Sandstone Range and Footslopes.

The Pindan Shrubland habitat (Plate 6) is most extensive covering most of the central and southern region. The geology of this habitat is characterised by flat plains, with weak orange to red sandy-loam soils. The dominant tree species is scattered *Corymbia greeniana*, over a moderately open to dense shrub layer consisting primarily of *Acacia tumida* var *tumida*, *Acacia platycarpa* and *Grevillea refracta*. The ground vegetation layer consists of a mix of grasses including *Triodia caelestialis*, *Aristida holathera* var *holathera*, *Crysopogon* sp., *Eriachne obtusa* and *Sorghum plumosum*. Leaf litter density is highly variable as a result of fire history and patchy shrub density.

Plate 6: Pindan Shrubland Habitat

The Sandstone Range and Footslopes habitat is the second most widespread within the study area found mainly across the northern region of the study area, but also extends partly down into the east. The geology is primarily undulating hills, slopes and gullies of orange sandy soils with sandstone residuals ranging from moderately dense pebbles to dense rocks. Several rock outcrops are also present in the eastern region of the study area (Plate 7 and Plate 8). The vegetation in this habitat is characterised by sparse *Corymbia dendromerinx* over moderately dense *Acacia drepanocarpa* subsp. *latifolia* over a ground vegetation layer of dense *Triodia caelestialis* hummock grassland and *Sorghum plumosum* tussock grassland.

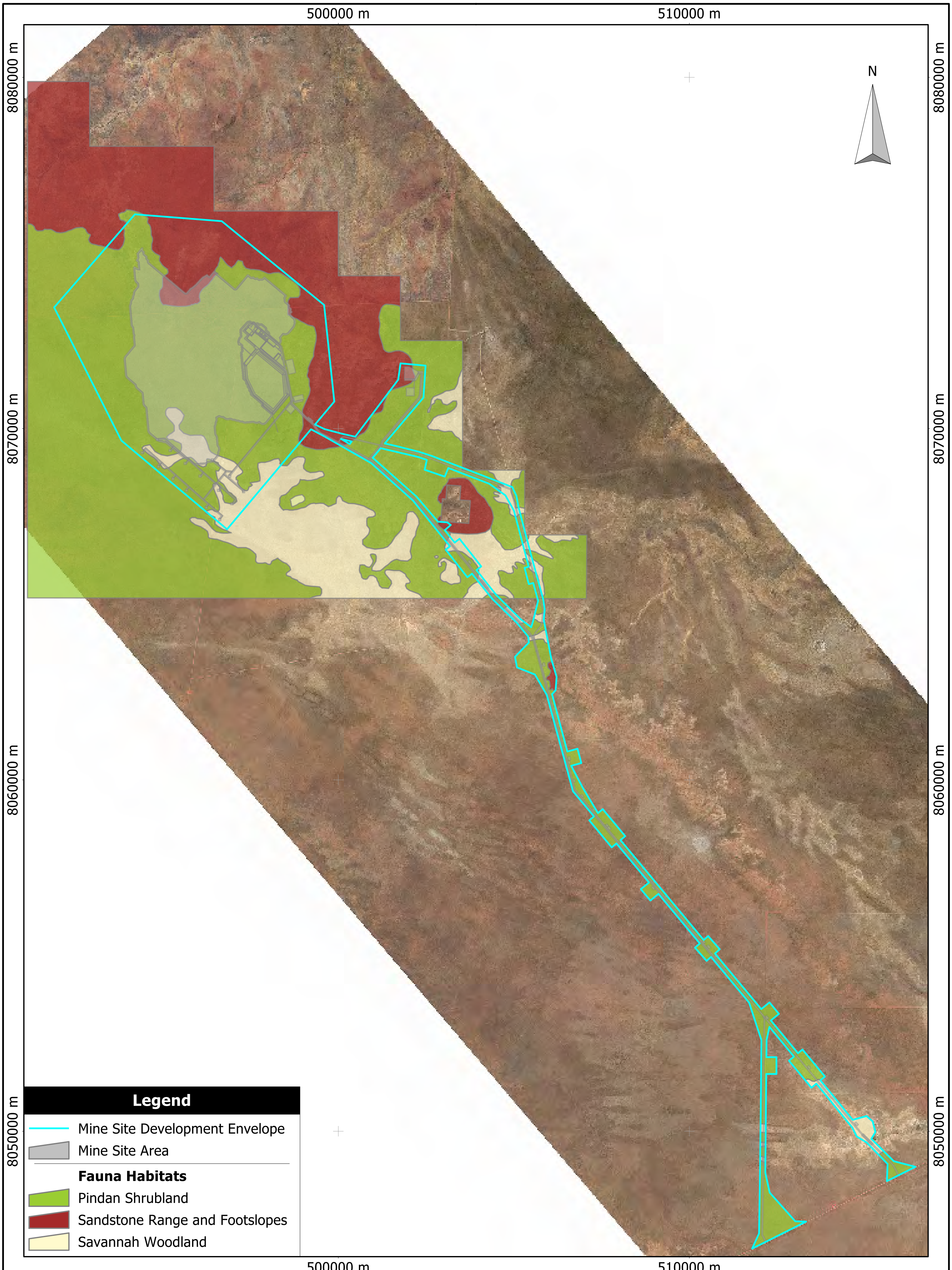
Plate 7: Undulating Rocky Hills in the Sandstone Range and Footslopes Habitat

Plate 8: Rock Outcrop in the Sandstone Range and Footslopes Habitat

The Savannah Woodland habitat is the least extensive, characterised by plains in the low-lying areas to the south and east of the study area, with firm brown-white sandy clay soils. The dominant vegetation consists of scattered *Eucalyptus tectifica* and *Brachychiton diversifolius*, with open to moderately dense shrubs of mainly *Acacia platycarpa*. There is a ground vegetation layer of *Eriachne obtusa* tussock grassland and *Triodia caelestialis* hummock grassland, and termite mounds are frequently present (Plate 9).

Plate 9: Savannah Woodland Habitat

A conceptual site layout over habitat type is shown in Figure 30.



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Original Size: A4
Air Photo Date: 2015
Grid: Australia MGA94 (51)
0 4 km

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Figure 30

Fauna Habitat of the Mine Site Development Envelope and Surrounding Area

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4.2.9.2 Fauna Species

Fauna surveys recorded a total of 20 mammals, 118 birds, 44 reptiles and 8 amphibians occurring within the Mine Site Development Envelope or surrounding areas. Of note was an approximate 80 km range extension of *Lerista apoda* (Dampier Land Limbless Slider) from coastal areas of the west coast of the Dampier Peninsula (Ecologia 2014a).

A comprehensive table of all the fauna species with potential to occur in the project area has been supplied in Appendix 10 as per Environmental Scoping Document requirements.

4.2.9.3 Conservation Significant Fauna

Fauna surveys identified a number of conservation significant fauna that have potential to occur within the Mine Site Development Envelope and surrounding areas. Appendix 10 lists these species and describes the likelihood of them occurring within the Mine Site Development Envelope. The locations of conservation significant species observed during project specific surveys is shown in Figure 31.

Nine conservation significant fauna species were recorded within the wider survey area, however, only three were recorded within the Mine Site Development Envelope as shown in Table 21 and Figure 31. These were the Greater Bilby, the Short-tailed Mouse, and the Rainbow Bee-eater; impacts to these species have been assessed in this Public Environmental Review. Species recorded in the wider survey area, but not in the Mine Site Development Envelope are the Fork-tailed Swift, Common Greenshank, Eastern Yellow Wagtail, Grey Wagtail, Wood Sandpiper, and the Dampierland Peninsula Goanna. In addition, suitable habitat for the Gouldian Finch, Oriental Pratincole, Dampierland Plain Slider, and Dampierland Burrowing Snake is present in the Mine Site Development Envelope.

The Bush-stone Curlew (*Burhinus grallarius*) and Australian Bustard (*Ardeotis australis*) were observed and reported by Ecologia (2012a) as being of conservation significance; however are no longer listed species.

Greater Bilby

The Greater Bilby (*Macrotis lagotis*) is listed as Vulnerable under the *EPBC Act* and Schedule 3 under the *WC Act 1950*. This species is the only surviving member of the Peramelidae family. It is characterised by soft silky fur that is ash grey over most of the body, except the belly which is pure white to cream. The tail is distinctive, with the first 20% being the same colour as the upper-body, the central 40% being black and the distal 40% pure white. The forelimbs have three stoutly clawed toes (and two unclawed toes) that enable the animal to burrow effectively. The long snout is well equipped with sensory vibrissae.

Mature males attain double the body mass of mature females (males 800 – 2,500g, females 600 – 1,100g), have longer canines and a noticeably enlarged forehead (Pavey 2006).

Once common throughout the arid and semi-arid regions of Australia, European settlement brought about changes to the Greater Bilby's habitat and as a result during the 20th century its range reduced significantly with the species now being absent from its previous southern and central range. Populations are now restricted to within the Tanami Desert of the Northern Territory, the Great Sandy and Gibson Deserts, parts of the Pilbara and Kimberley regions of Western Australia and the clayey and stony soils of the Mitchell grasslands of southwest Queensland.

Bilbies are largely solitary, widely dispersed and found in low numbers. Contemporary habitat utilisation was investigated in the mid-1980s; Southgate (1990) reported that a broad range of environments were still occupied by the Greater Bilby and recognised three major vegetation types:

- Open tussock grasslands (grasses and forbs) growing on uplands and hills.
- Mulga woodlands/shrublands (pure mulga and mixed stands of mulga/witchetty bush) growing on ridges and rises.

- Hummock grasslands growing on sand plains and dunes, drainage systems, salt lake systems and other alluvial areas.

In the Kimberley region of Western Australia, Bilbies have been recorded in similar habitats, typically in areas with soft, sandy substrates, such as eolian sand dunes, swales and sandplains, which can be easily excavated to construct burrows and dig for food. It is likely that bilbies have a preference for habitats with easily excavated substrates. Consequently, it is possible that the bilbies would find man-made earth structures such as topsoil stockpiles to be ideal for burrowing.

The Greater Bilby usually spends the daytime in burrows up to 3 m deep, often built against termite mounds, spinifex hummocks or shrubs, coming out at night to forage. Over a dozen burrows may be used by the same individual within its home range (Southgate 1987).

The Greater Bilby has an opportunistic feeding strategy and forages on insects, bulbs and fruit, with a wide range of plant and animal taxa being consumed. This strategy enables it to survive in arid regions despite the unpredictable temporal and spatial availability of food resources (Gibson 2001). Populations are known to move long distances when habitat ranges become unsuitable.

The impact of predators such as foxes and cats has had the greatest impact on Greater Bilby populations and continues to be the most serious threat to their survival. The addition of artificial water points within arid zones has contributed to their decline, primarily as a result of these predators being able to roam over greater areas when provided with access to additional water points.

Fragmentation, degradation and destruction of Greater Bilby habitat is also increasing as a result of indirect competition for food with exotic species (such as rabbits), presence of feral and domestic herbivores, changed fire regimes, increased development, drought, and road mortality (DEHP 2016).

During the Targeted Bilby survey, Ecologia reported 754 records of Bilby activity, evidenced by diggings (670 records), scats (25 records), active and inactive borrows (17 and 42 records respectively). Bilby presence was also confirmed at two active burrows using motion sensor cameras.

Scats observed during the targeted Bilby survey underwent DNA analysis. The results indicated that at the time of the survey, at least nine individuals utilised the area in the vicinity of the Mine Site.

In the broader region surrounding the proposed Mine Site, the Greater Bilby has been reported within open woodland and open forest pindan vegetation types, with occurrence in pindan shrubland and other vegetation communities having a lower degree of preference.

During the Targeted Bilby survey at the Thunderbird Mineral Sand Project, evidence of Bilby occurrence was primarily recorded within the Pindan Shrubland vegetation type. More specifically, within the Mine Site Development Envelope, the Bilby was recorded predominantly within dense, mature *Acacia tumida var. tumida* woodland micro-habitat. This micro-habitat appears to be influenced by fire age, with older fire age (>2 years) than surrounding areas. The dense, mature *Acacia tumida var. tumida* woodland micro-habitat forms a dense canopy layer, but relatively open ground cover, which is in contrast to surrounding areas which appear to have been burnt more frequently and are characterised by dense ground vegetation.

Short-tailed Mouse

The Short-tailed Mouse (*Leggadina lakedownensis*) also known as the Lakeland Downs Short-tailed mouse is listed as Priority 4 by DPaW. It is a small elusive rodent that occupies a diverse range of habitats from monsoon tropical coasts to semi-arid climates, including spinifex and tussock grasslands, samphire and sedgelands, *Acacia* shrublands, tropical eucalypt and *Melaleuca* woodlands and stony ranges. Populations fluctuate greatly in response to rainfall and seasonal food availability (Ecologia 2015).

This species is nocturnal and spends its days in small burrows, coming out at night to feed. The Short-tailed Mouse is omnivorous, feeding on a variety of invertebrates and plant material. The amount of invertebrate material varies with the time of year, and is consumed more during the dry periods when plant water content is low (DPaW 2016d).

One individual was recorded by Ecologia within the Mine Site Development Envelope at a trap site consisting of tussock grasses.

Rainbow Bee-eater

The Rainbow Bee-eater (*Merops ornatus)* is listed as Schedule 5 under the *WC Act*.

It is scarce to common throughout much of Western Australia, except for the arid interior, preferring lightly wooded, preferably sandy country near water (Johnstone and Storr 1998).

In WA the Rainbow Bee-eater may occur as a resident, breeding visitor, post-nuptial nomad, passage migrant or winter visitor. It nests in burrows usually dug at slight angles on flat ground, sandy banks or cuttings. Eggs are laid from August to January and are most susceptible to predation during breeding as it spends significantly more time on the ground during this period (Ecologia 2015).

The Rainbow Bee-eater was recorded 57 times during the Mine Site Development Envelope surveys (2014 and 2015), 41 of which were within the proposal area (Ecologia 2014a and 2015). Two Rainbow Bee-eater nests were also recorded. Based on the transient nature of this species and the amount of habitat available in, and surrounding, the Mine Site Development Envelope, it is considered highly probable that this species will occur in the wider area.

Fork-tailed Swift

The Fork-tailed Swift (*Apus Pacificus)* is a marine species listed under the *EPBC Act* as migratory and Schedule 3 under the *WC Act.* It is a small, insectivorous species with a white throat and rump, and a deeply forked tail (Morcombe 2000) with distribution ranging from central Siberia and throughout Asia. The Fork-tailed Swift is a relatively common trans-equatorial migrant, arriving in WA between September and December each year. This species overwinters in Australia and south New Guinea, and breeds in north-east and mid-east Asia (Ecologia 2015).

Forked-tailed Swifts are nomadic in response to broad scale weather pattern changes and are attracted to thunderstorms. They rarely land, living almost exclusively in the air, feeding entirely on aerial insects, especially swarms of beetles, ants, termites, and native bees (Simpson and Day 2004; Ecologia 2015).

Two Fork-tailed Swifts were recorded flying over the Mine Site Development Envelope in 2013; subsequent surveys in 2014 and 2015 have not recorded this species again (Ecologia 2014a). The species is considered a transient visitor to the Mine Site Development Envelope (Ecologia 2014a, 2015) and may at times be found in varying numbers foraging in the air above the project area.

Common Greenshank

The Common Greenshank (*Tringa nebularia*) is listed as migratory species under the *EPBC Act*, Schedule 3 under the *WC Act* and has an Intentional Agreement under DPaW It is a large, rather heavily built wader, which is mainly grey-brown above and pale below. The head and neck are flecked with dark grey and the bill is dark to green-grey with a long slight upward curve (Birdlife 2016).

The species breeds in the Palaearctic regions and is widespread in Africa, coastal Asia, the Indian subcontinent, the Philippines, and southern New Guinea. They are common throughout Australia in the summer months as a non-breeding visitor to well-watered regions that can be observed in all months of the year and normally remain in the same locations with some local movement (Ecologia 2015).

Greenshanks eat insects, worms, molluscs, small fish and crustaceans both along the coast and inland in estuaries and mudflats, mangrove swamps, lagoons, billabongs, swamps, sewage farms, and flooded crops.

Two Common Greenshanks were observed foraging at a turkey's nest dam containing water not far from the Great Northern Highway within the savannah woodland habitat, but outside the Mine Site Development Envelope. The Common Greenshank has a medium likelihood of occurrence of being found within small drainage lines which occur in the savannah woodland habitats and low lying landscape features and grasslands should these areas flood during the wet season to create suitable foraging habitats (Ecologia 2015).

Eastern Yellow Wagtail

The Eastern Yellow Wagtail (*Motacilla tschutschensis*) is listed as migratory under the *EPBC Act* and Schedule 3 under the *WC Act*. It is a small passerine in the wagtail family. It is a slender 15–16 cm long bird, with the characteristic long, constantly wagging tail of its genus. The breeding adult male is olive above and yellow below. In other plumages, the yellow may be diluted by white.

This species feeds on the ground or along the edge of very shallow waters where they pick small insects from the ground after a short chase or bounce in the air. The diet consists almost entirely of insects including midges and other flies, beetles, aphids, ants, and many others (Ecologia 2014a).

The Eastern Yellow Wagtail breeds in temperate Asia and has a foothold in North America in Alaska. Populations migrate to south Asia and Australia.

Two individuals of this species were recorded at Mt Jowlaenga homestead (outside the Mine Site Development Envelope) during the 2014 survey (Ecologia 2014a). The Eastern Yellow Wagtail has a medium likelihood of occurrence within small drainage lines which occur in the savannah woodland habitats, low lying landscape features, and grasslands, should these areas flood during the wet season to create suitable foraging habitats (Ecologia 2015).

Grey Wagtail

The Grey Wagtail (*Motacilla cinerea*) is listed as migratory under the *EPBC Act* and Schedule 3 under the *WC Act*. It measures around 18 – 19 cm overall in length and looks somewhat similar to the Yellow Wagtail but has the yellow on its underside restricted to the throat and vent. The species is widely distributed, with several breeding populations in Europe and Asia, migrating to tropical regions in Asia and Africa, and occasionally Australia.

The species is almost always associated with running water during the breeding season. Outside the breeding season they can occupy areas around lakes, coasts, and other watery habitats. The diet of the Grey Wagtail consists of a variety of aquatic invertebrates including adult flies, mayflies, beetles, crustaceans, and molluscs (Johnstone and Storr 2004).

One individual was recorded at Mt Jowlaenga homestead (outside the Mine Site Development Envelope) during the 2014 survey (Ecologia 2014a). The Grey Wagtail has a medium likelihood of occurrence within small drainage lines which occur in the savannah woodland habitats and low lying landscape features and grasslands should these areas flood during the wet season to create suitable foraging habitats (Ecologia 2015).

Wood Sandpiper

The Wood Sandpiper (*Tringa glareola*) is listed as migratory under the *EPBC Act* and Schedule 3 under the *WC Act*. It is a small slim, sharp-tailed wader which is dark grey-brown above, with light flecks or spots, and a white underbody. The legs are yellow-green, and the bill is black. Their flight is strong, with distinctive clipped wing beats (Simpson and Day 2004). The species can often be seen in small flocks or singly on inland shallow freshwater wetlands; however they prefer ponds and pools with emergent reeds and grass surrounded by tall plants. In Australia the species can typically be found around the muddy or grassy edges of freshwater wetlands where they feed mainly on aquatic insects and their larvae, as well as molluscs (Birdlife 2016).

The Wood Sandpiper is a trans-equatorial migratory species which breeds widely in subarctic wetlands from the Scottish Highlands across Europe and Asia. They migrate to Africa, southern Asia, particularly India and Australia to overwinter in the southern hemisphere. The species is a regular migrant to WA in small numbers, mostly between August and May (Johnstone and Storr 1998; Ecologia 2015).

Twelve individuals of this species were recorded at Mt Jowlaenga Homestead (outside the Mine Site Development Envelope) during the 2013 survey. The Wood Sandpiper has a medium likelihood of occurrence within small drainage lines which occur in the savannah woodland habitats, low lying landscape features, and grasslands, should these areas flood during the wet season to create suitable foraging habitats (Ecologia 2015).

Dampier Peninsula Goanna

The Dampier Peninsula Goanna (*Varanus sparnus*) is listed as Priority 1 by DPaW. Recent fauna surveys conducted by the West Australian Museum on the Dampier Peninsula identified unusual specimens of *Varanus brevicauda*. Subsequent morphological and molecular genetic appraisals identified a new species *Varanus sparnus*. *V. Sparnus* is slightly smaller than *V. brevicauda* in maximum body size, making it the smallest known Varanus. The new species is currently only known from four individuals collected from two locations about 90 km apart in the central portion of the Dampier Peninsula which represent the specimens used to describe the species (Doughty et al. 2014). The known distribution extends from coastal areas at Coulomb Point to central Dampier Peninsula. Specimens were collected from habitats broadly described as Pindan Shrubland with sandy soils associated with alluvial or sandstone deposits (Doughty *et al*. 2014). The species regularly excavates and lives in burrows (Doughty et. al. 2014) and thus any soil substrate on the Dampier Peninsular able to be excavated could currently be considered as potential suitable habitat.

One confirmed *V. sparnus* individual was recorded during the haul road survey outside the Mine Site Development Envelope. Eleven further individuals were also identified during this survey however they were not able to be identified definitively in the field as either *Varanus sparnus* or *Varanus brevicauda*.

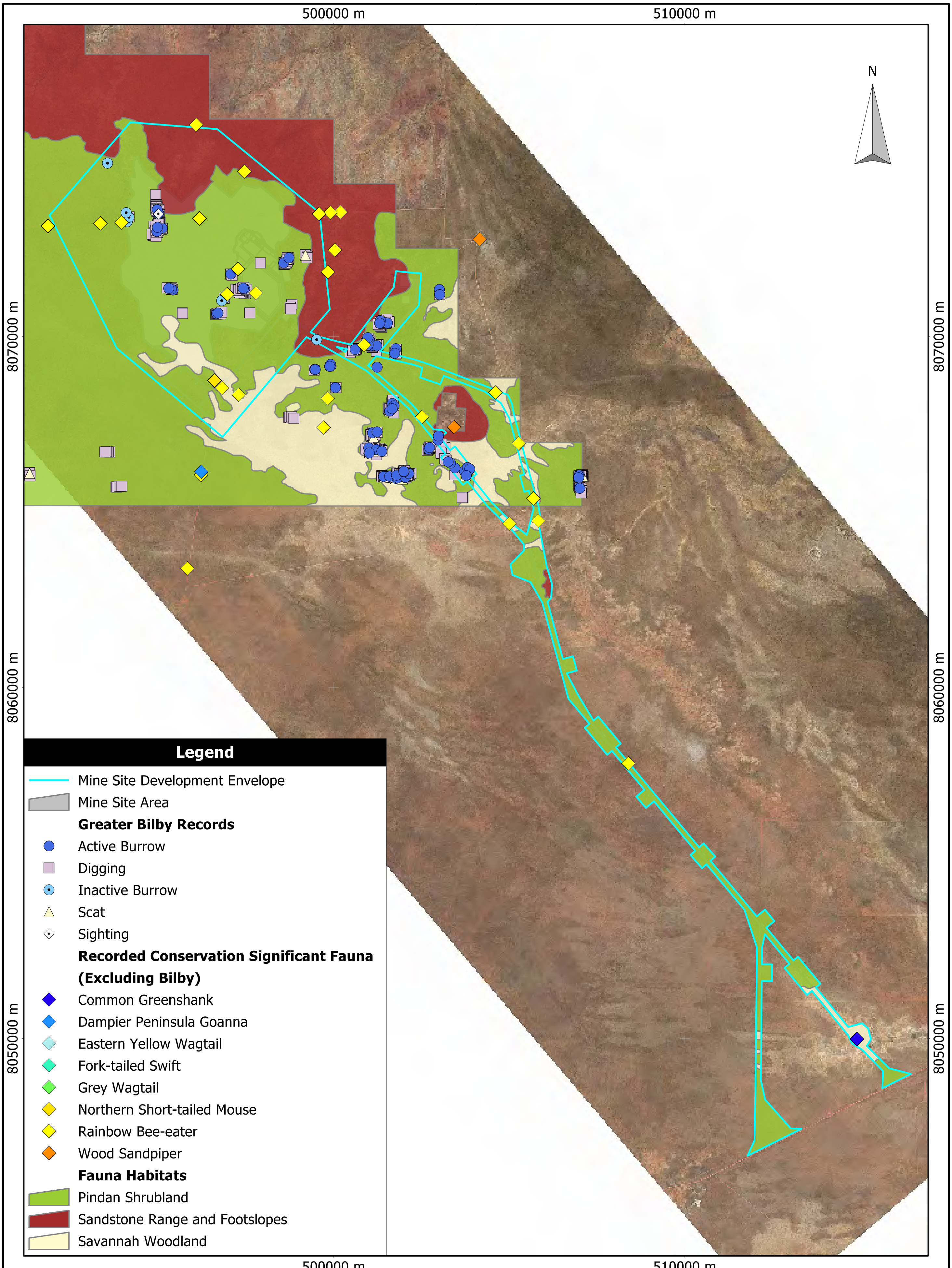
Table 22: Conservation Significant Species with Potential to Occur in Mine Development Envelope and/or Surrounding Areas

Species	Conservation Significance			Habitat	Likelihood of Occurrences	Recorded during Surveys
	EPBC Act	WC Act	DPaW			
Mammals						
Dasycercus cristicauda Crest-tailed Mulgara	VU	S1		Sandy areas predominately on the top of sand dunes at the base of large Canegrass clumps or Nitre Bush hummocks.	Low - No suitable habitat. Not previously recorded within 100 km of the Study Area.	No
Dasyurus hallucatus Northern Quoll	EN	S1	EN	Rocky areas, also eucalypt forest and woodland.	Low - Some suitable habitat in rocky hills, but not previously recorded on Dampier Peninsula.	No
Hipposideros stenotis Northern Leaf-nosed Bat			P2	Sandstone caves.	Low - No potential roost caves. Not previously recorded on Dampier Peninsula	No
Isoodon auratus auratus Golden Bandicoot	VU	S1		Rocky sandstone spinifex and vine thickets.	Low - Few records within 100 km, and limited suitable habitat.	No
Leggadina lakedownensis Short-tailed Mouse			P4	Spinifex and tussock grassland on cracking clays. Also acacia shrubland, samphire, woodlands, and stony ranges.	High - Suitable habitat occurs throughout the area.	Yes
Macroderma gigas Ghost Bat			P4	Caves, rock piles and abandoned mines.	Low - No potential roost caves. Not previously recorded on Dampier Peninsula	No
Macrotis lagotis Bilby	VU	S1	VU	Variety of habitats on soft soil, including spinifex grassland, acacia shrubland, open woodland, and cracking clays.	High - Suitable habitat occurs in the area	Yes
Mormopterus loriae cobourgiana Mangrove Freetail Bat			P1	Roost in mangrove stands, hunt in mangroves and forests.	Low - No suitable habitat within the study area.	No
Rhinonicteris aurantius Golden Horseshoe Bat	VU	S1	VU	Roost in caves with high humidity (95%) and temperature (32 °C). Forage along waterbodies with fringing vegetation.	Low - No potential roost caves. Not previously recorded on Dampier Peninsula	No
Vespadelus douglasorum Yellow-lipped Cave Bat			P2	Tropical woodlands of West Kimberley	Low - No potential roost caves. Not previously recorded on Dampier Peninsula	No
Birds						
Ardea ibis Cattle Egret	M	S3		Grassy habitats and wetlands, particularly damp pastures.	Low - Very little suitable habitat, but may occur during the wet season in open flooded depressions.	No

Species	Conservation Significance			Habitat	Likelihood of Occurrences	Recorded during Surveys
Apus pacificus Fork-tailed Swift	M	S3		Almost entirely aerial, particularly associated with storm fronts.	High - A relatively common summer migrant in the northwest of Australia that will occasionally forage in the aerial space above the Study Area.	Yes (Not within Mine Site Development Envelope)
Ardea modesta Eastern Great Egret	M	S3		Floodwaters, rivers, shallows of wetlands, intertidal mud-flats.	Low - Very little suitable habitat, but may occur during the wet season in flooded depressions.	No
Calidris acuminata Sharp-tailed Sandpiper	M	S3		Coasts and well-watered parts of the interior. Prefer grassy areas of non-tidal fresh or brackish wetlands, coastal marshes and tidal flats.	Medium - Suitable habitat occurs within the Study Area.	No
Calidris melanotos Pectoral Sandpiper	M	S3		Uncommon in WA. Shallow, fresh waters, often with low grass or other herbage; swamp margins, flooded pastures, sewage ponds; occasionally tidal areas, saltmarshes. Breeds in Arctic.	Low - Suitable foraging habitat may occur within the Study Area.	No
Calidris ruficollis Red-necked Stint	M	S3		Coastal areas: sheltered inlets, bays, lagoons and estuaries with intertidal mudflats, often near spits, islets and banks; also saline and freshwater inland wetlands.	Medium – Suitable foraging habitat may occur within the Study Area.	No
Calidris subminuta Long-toed Stint	M	S3		Shallow water surrounded by dense low vegetation.	Medium - Suitable foraging habitat may occur within the Study Area.	No
Charadrius veredus Oriental Plover	M	S3		Bare rolling country; bare claypans; open ground near inland swamps.	Medium - Suitable foraging habitat may occur within the Study Area.	No
Chlidonias leucopterus White-winged Black Tern	M	S3		Mainly estuaries and sheltered seas in north, freshwater lakes and swamps in south.	Low - Suitable foraging habitat may occur within the Study Area	No
Erythrotriorchis radiatus Red Goshawk	VU	S1	VU	Open forests and woodlands, tropical savannas traversed by wooded rivers, rainforest margins, and gorge and escarpment country	Low - Suitable foraging habitat may occur within the Study Area.	No
Erythrura gouldiae Gouldian Finch	EN		P4	Tropical savannas; breed in rocky hills with hollow-bearing eucalypts near water.	Medium - Suitable habitat occurs within the Study Area. However, known from very few locations on Dampier Peninsula.	No
Falco hypoleucos Grey Falcon		S1	VU	Lightly wooded coastal and riverine plains.	Low - Little suitable habitat within the Study Area.	No

Species	Conservation Significance			Habitat	Likelihood of Occurrences	Recorded during Surveys
Falco peregrinus Peregrine Falcon		S4	Other	Coastal cliffs, riverine gorges and wooded watercourses.	Low - Little suitable habitat within the Study Area.	No
Gallinago megala Swinhoe's Snipe	M	S3		Shallow freshwater wetlands of various kinds including paddy fields and sewage farms, with bare mud or shallow water for feeding, with nearby vegetation cover	Low - Suitable foraging habitat may occur within the Study Area	No
Glareola maldivarum Oriental Pratincole	M	S3		Plains, shallow wet and dry edges in open bare wetlands, tidal mudflats, beaches.	Medium - Suitable habitat exists within the study area, and there are records nearby.	No
Haliaeetus leucogaster White-bellied Sea-Eagle	M	S3		Coastal and near coastal water bodies.	Low - Very little suitable habitat, but may occur during the wet season in open flooded depressions.	No
Hirundo rustica Barn Swallow	M	S3		Open country, agricultural land, especially near water.	Low - Little suitable habitat within the Study Area.	No
Merops ornatus Rainbow Bee-eater		S5		Open country, most vegetation types, dunes, banks.	High - Some nesting habitat present along drainage lines.	Yes
Motacilla cinerea Grey Wagtail	M	S3		Predominantly banks and rocky areas along flowing freshwater habitats	Medium - Suitable habitat exists within the study area.	Yes (Not within Mine Site Development Envelope)
Motacilla tschutschensis Eastern Yellow Wagtail	M	S3`		Short grasslands (usually damp or watered), swamp margins, sewage ponds, bore overflows, and irrigated areas	Medium - Suitable habitat exists within the study area.	Yes (Not within Mine Site Development Envelope)
Neochmia ruficauda subclarescens Star Finch (western)			P4	Vegetation around watercourses, particularly thick reed beds.	Low - Little suitable habitat within the Study Area.	No
Numenius minutus Little Curlew	M	S3		Short dry grasslands, including artificial grassed areas.	Medium - Suitable habitat exists within the study area.	No
Pandion cristatus Eastern Osprey	M			Mangroves, rivers, estuaries, inland seas, coastal islands.	Low - Little suitable habitat within the Study Area.	No
Phaps histrionica Flock Bronzewing			P4	Sparsely wooded plains near water. Nomadic visitor to areas of suitable habitat.	Low - Little suitable sparsely wooded habitat.	No

Species	Conservation Significance			Habitat	Likelihood of Occurrences	Recorded during Surveys
Plegadis falcinellus Glossy Ibis	M	S3		Shallows and adjacent flats of freshwater lakes and swamps; river pool; flooded samphire; sewage ponds. Nest in freshwater/brackish wetlands with tall, dense stands of emergent vegetation and low trees or bushes.	Low - Very little suitable habitat, but may occur during the wet season in flooded depressions.	No
Australian Painted Snipe Rostratula australis	EN, M	S1, S3	EN	Shallow, vegetated wetlands	Low - Very little suitable habitat, but may occur during the wet season in flooded depressions.	No
Tringa glareola Wood Sandpiper	M	S3		Mainly shallow, fresh waters, river pools, claypans; occasionally brackish swamps; rarely salt lakes, estuaries and intertidal mudflats.	High – Suitable habitat in the study area.	Yes (Not within Mine Site Development Envelope)
Tringa nebularia Common Greenshank	M	S3		Intertidal mudflats, estuaries, freshwater and saline wetlands along the coast and inland.	High – Suitable habitat in the study area.	Yes (Not within Mine Site Development Envelope)
Turnix castanota Chestnut-backed Button-quail			P4	Savannah woodlands in sandstone and lateritic country.	Low - Little suitable habitat and no records nearby.	No
Tyto novaehollandiae Masked Owl			P1	Forest, woodland, caves, mature trees with hollows.	Low - Little suitable habitat within the Study Area. Not known from Dampier Peninsula.	No
Reptiles						
Crocodylus porosus Salt-water Crocodile		S4	Other	Tidal rivers, coastal floodplains and channels, billabongs and swamps up to 150 km inland.	Low - No suitable habitat within the Study Area.	No
Lerista separanda Dampierland Plain Slider			P2	Sandy areas.	Low - Little suitable habitat within the Study Area.	No
Simoselaps minimus Dampier Burrowing Snake			P2	Coastal dunes or sandy areas between dunes and adjacent acacia shrublands.	Low - No suitable habitat within the Study Area.	No
Varanus sparnus Dampierland Peninsula Goanna			P1	Sandy areas.	High – Suitable habitat within the Study Area	Yes (Not within Mine Site Development Envelope)



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Original Size: A4
Air Photo Date: 2015
Grid: Australia MGA94 (51)
0 4 km

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Figure 31

Location of Conservation Significant Fauna Observations

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Gouldian Finch

The Gouldian Finch (*Erythrura gouldiae*) is listed as Endangered under the *EPBC Act* and Priority 4 by DPaW. It is a small bird, with a bright green back, yellow belly and purple breast. The facial colour is usually black, and is found in about 75% of the birds. Red-faced forms make up about 25% of the population, and rare, yellow-faced birds occur from time to time. The yellow colour results from a lack of red pigment in the red-faced birds.

The Gouldian Finch occurred throughout tropical savannahs of northern Australia; however it is now restricted to isolated areas mostly within the Northern Territory and Kimberley region of Western Australia (Woinarski and Palmer 2006). Breeding habitat is characterised by rocky hills with hollow-bearing, smooth-barked gums that are close to small waterholes or springs that persist through the dry season. As is common in most grassfinch species, the Gouldian Finch is seldom found far from water, and needs to drink several times during the day.

This species forages on the ground, feeding predominantly on seeding grasses, particularly native *Sorghum* spp. (Pizzey and Knight 2003). Due to this very restricted diet, they are particularly vulnerable to seed shortages (O'Malley 2006). The decline in populations of the Gouldian Finch is representative of the general decline of granivorous birds occurring as a result of current land management practices.
This species was not recorded during surveys of the Mine Site Development Envelope; however the study area did contain suitable foraging and breeding habitat. Given the scarcity of surrounding records of the species there is only a medium likelihood of it occurring, and based on current knowledge will most likely be a transient visitor.

Oriental Pratincole

The Oriental Pratincole (*Glareola maldivarum*) is listed as migratory under the *EPBC Act*, Schedule 3 under the *WC Act* and under the DPaW international Agreement. It is an atypical wader, with sandy brown above and paler brown below, with a white rump and black primaries and tail. The buffy throat is edged by a thin black band and the underwings are chestnut. The bill is short and black, with red at the base; legs are slim and dark.

The Oriental Pratincole is a non-breeding migrant to Australia, which breeds in Mongolia, Siberia, and China and further south to Sri Lanka, Thailand, and Vietnam. It overwinters in northern Australia (Johnstone and Storr 1998). Oriental Pratincoles occur on open plains, bare ground around swamps, and claypans.

An unusual feature of the pratincoles is that although classed as waders, they typically hunt their insect prey on the wing like swallows, although they can also feed on the ground. Birds may feed in the evening until nearly dark (Johnstone and Storr 1998).

The Oriental Pratincole was not recorded during the surveys of the Mine Site Development Envelope, however it has a medium likelihood of occurrence as suitable habitat exists in the Savannah Woodland habitat type, which contains small drainage lines and occurs in low lying landscape features and grasslands. Should these pastures flood during the wet season, then temporary suitable foraging habitat may exist for this species.

Dampierland Plain Slider

The Dampierland Plain Slider (*Lerista separanda*) is listed as Priority 2 by DPaW. It is currently known to be found in sandy soils along the southwest Kimberley coastline, between Kimbolton and Nita Downs (Wilson and Swan 2010). It is one of the smallest species in the genus and has a fused lower eyelid (Wilson and Swan 2010). Whereas most other Lerista species have greatly reduced or only two limbs, *L. separanda* has four of the relatively largest limbs.

This species is apparently restricted to coastal habitats, however it is a poorly known species and as sandy habitat occurs within the Pindan Shrubland habitat of the Mine Site Development Envelope, it is possible that the species will occur in the area.

Dampierland Burrowing Snake

The Dampierland Burrowing Snake (*Simoselaps minimus*) is listed as Priority 2 by DPaW. It is currently known only from the western side of the Dampier Peninsula. Its preferred habitat is on coastal dunes or the sandy areas between dunes and adjacent *Acacia* shrublands (Wilson and Swan 2010).

Little is known about this species however it is presumed to be similar to other *Simoselaps* species, which are sand-swimmers which feed mostly on *Lerista* skinks.

The Dampierland Burrowing Snake was not recorded during surveys of the Mine Site Development Envelope, however given the sandy soils are characteristic of the Pindan Shrubland and Savannah Woodland habitats, the Dampierland Burrowing Snake may occur within the area.

4.2.9.4 Introduced Fauna

A total of four introduced mammal species were recorded in the Mine Site Development Envelope (Ecologia 2012a, 2014a, 2015):

- Dog/Dingo (*Canis lupus*).
- Cat (*Felis catus*).
- Cow (*Bos taurus*).
- House Mouse (*Mus musculus*).

4.2.9.5 Short Range Endemics

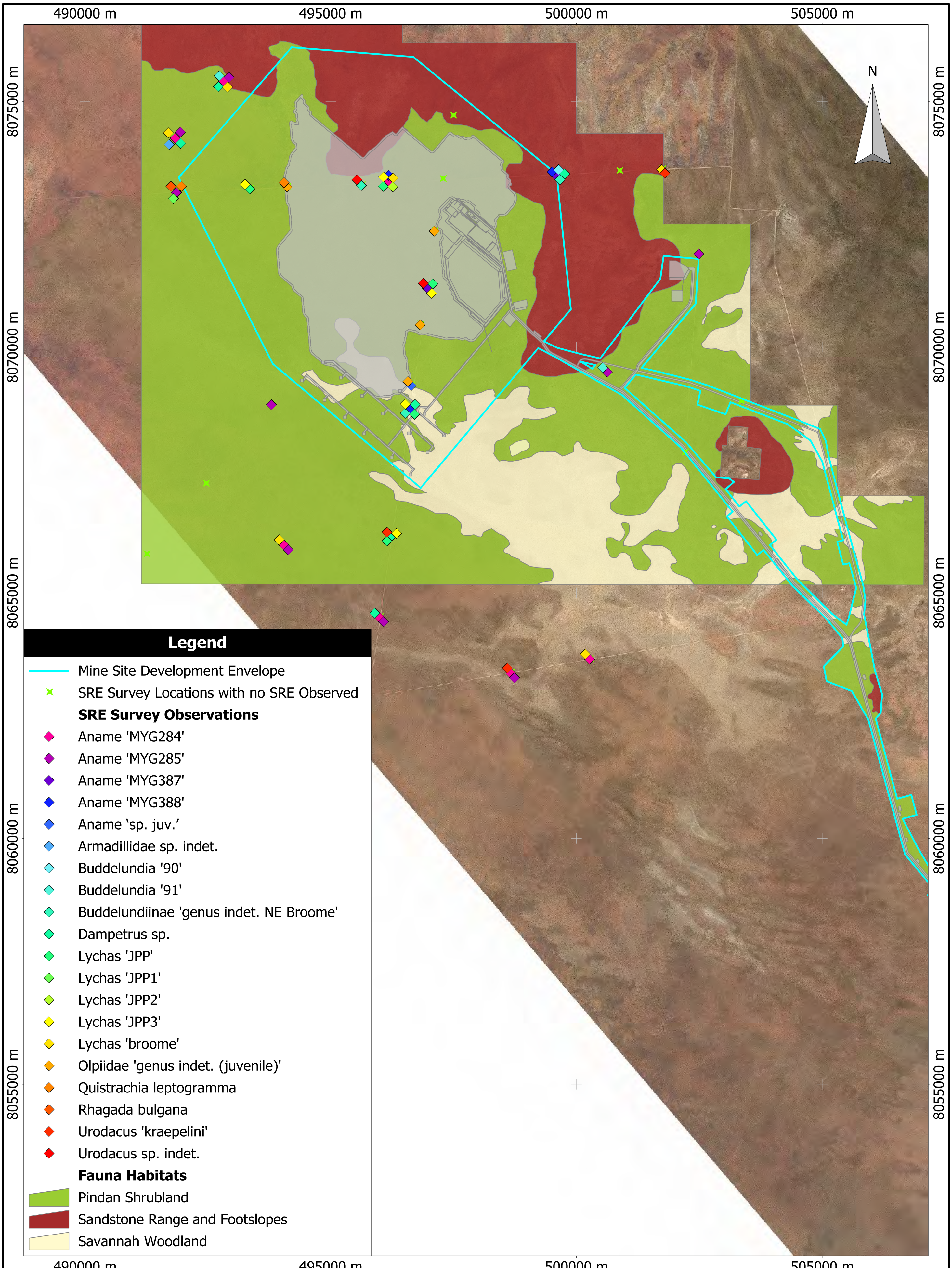
A Level 2 Short Range Endemic (SRE) survey was undertaken by Ecologia in March 2014 (Ecologia 2014a), followed by a targeted survey in December 2014 (Ecologia 2014c), are attached as Appendix 9.

The surveys yielded a total of 200 invertebrate specimens with a total of 6 orders, 11 families, and 31 taxa. Of these species, 22 were identified as being potential SRE, with one species (the land snail *Rhagada bulgana*) confirmed as a SRE (Table 23). The distribution of SREs at the Mine Site Development Envelope is depicted in Figure 32.

Of the 23 confirmed and potential SREs:

- Seventeen were found in similar habitats outside the Mine Site Development Envelope.
- Three (*Olpiidae* 'genus indet. (Juvenile)', *Aname* 'sp. Indet.' and *Aname* 'sp. Juv.') were represented by juveniles and due to a lack of morphological data and sub-adult stage could not be identified to species level. Given that all three of these specimens were collected from the extensive Pindan Shrubland habitat throughout the impact area, they are likely to have distributions that extend well beyond the boundary of the impact area.
- One (*Urodacus* sp. Indet) was unable to be identified to species level based on morphological characteristics, however based on distribution patterns of *Urodacus* 'kraepelini' and given this species was collected from the extensive Pindan Shrubland habitat, its distribution is expected to extend well beyond the boundary of the impact area.
- One (*Aname* 'MYG387?') was represented by a single female specimen. It is possible that this female is conspecific with the male species of *Aname* 'MYG387', which would indicate that its habitat preferences includes both the extensive Pindan Shrubland and Sandstone Range and Footslopes habitats, and is therefore widespread in the area.
- One (*Lychas* 'JPP2') was restricted to the impact area, however utilising *Lychas 'JPP', 'JPP1'* and *'JPP3'* as species surrogates and based on their distribution within the extensive Pindan Shrubland and Savannah Woodlands habitats it can be inferred that *Lychas* 'JPP2' will have a home range that extends well beyond the impact area.

Based on the above results as well as the habitat preferences for the invertebrate taxa recorded within the Mine Site Development Envelope and surrounding area, no potential SRE taxa are expected to be restricted to the proposed Mine Site Development Envelope.



Scale: 1:100000 Original Size: A4 Air Photo Date: 2015 Grid: MGA94(51) 0 2 km	Sheffield Resources Limited Thunderbird Mineral Sands Project	**Figure 32** **Location of SRE Observations**	Martinick Bosch Sell Pty Ltd 4 Cook St West Perth WA 6005 Ph: (08) 9226 3166 Fax: (08) 9226 3177 info@mbsenvironmental.com.au www.mbsenvironmental.com.au MBS ENVIRONMENTAL

W:\Sheffield Resources\PER\Drawings\PER Map.map 21/12/2016 F32 Location of SREs A4P

Table 23: SREs Collected from the Mine Site Development Envelope

Order	Family	Species	SRE Status	Survey		Presence Confirmed Outside Development Envelope
Mygalomorphae (Spiders)	Nemesiidae	*Aname* 'MYG284'	Potential	X	X	Yes
		Aname 'MYG285'	Potential	X	X	Yes
		Aname 'MYG387'	Potential	X		Yes
		Aname 'MYG387?'	Note 1	X		No
		Aname 'MYG388'	Potential	X		Yes
		Aname 'sp. indet.'	Note 2 and 3	X		No
		Aname 'sp. juv.'	Note 2 and 3	X		No
Arachnida (Opiliones)	Assamiidae	*Dampetrus* sp.	Potential	X	X	Yes
Scorpiones (Scorpions)	Buthidae	Lychas 'annulatus'	No	X		Yes
		Lychas 'broome'	Potential	X	X	Yes
		Lychas 'JPP'	Potential	X		Yes
		Lychas 'JPP1'	Potential	X		Yes
		Lychas 'JPP2'	Potential	X		No
		Lychas 'JPP3'	Potential	X		Yes
		Lychas 'multipunctatus'	No	X	X	Yes
	Urodacidae	*Urodacus 'kraepelini'*	Potential	X	X	Yes
		Urodacus sp. indet.	Note 2	X		No
Pseudoscorpiones	Sternophoridae	*Afrosternophorus* sp. indet.	No	X		Yes
	Chernetidae	*Haplochernes* sp. Indet.	No	X		Yes
	Olpiidae	*Beierolpium* 'sp. 8/4'	No	X		Yes
		Olpiidae 'genus indet. (juvenile)'	Note 2 and 3	X		No
		Indolpium'sp. Indet.'	No		X	Yes
Isopoda (Slaters)	Armadillidae	*Armadillidae* 'EE1501C'	Potential	X	X	Yes
		Buddelundiinae 'genus indet. NE Broome'	Potential	X	X	Yes
		Buddelundiinae sp. 74	Potential	X	X	Yes
		Buddelundia sp. '90'	Potential		X	Yes
		Buddelundia sp. '91'	Potential		X	Yes
Gastropoda (Snails)	Subulinidae	*Eremopeas interioris*	No	X		Yes
	Pupillidae	*Pupoides pacificus*	No	X		Yes
	Camaenidae	*Quistrachia leptogramma*	Potential	X		Yes
		Rhagada bulgana	Confirmed	X		Yes

Note 1: Single female specimen captured. Could be conspecific with Aname 'MYG387'.

Note 2: Specimen was unable to be identified to species level.

Note 3: Only juveniles collected.

4.2.10 Subterranean Fauna

A Level 2 subterranean fauna survey of the Mine Site Development Envelope was undertaken by Ecologia in March 2014 (Ecologia 2014a) (Appendix 9). A total of 21 drill holes (located within and outside the Mine Site Development Envelope) from within the Broome Sandstone Aquifer were sampled for troglofauna and stygofauna species as represented in Figure 33.

The subterranean fauna sampling was said to be tapping the Broome Sandstone Aquifer, a non-karstic, unconfined aquifer. The majority of this area is dominated by clays and sand strata (pindan units), which consequently suggests limited saturated habitat space beneath the watertable (Ecologia 2014a).

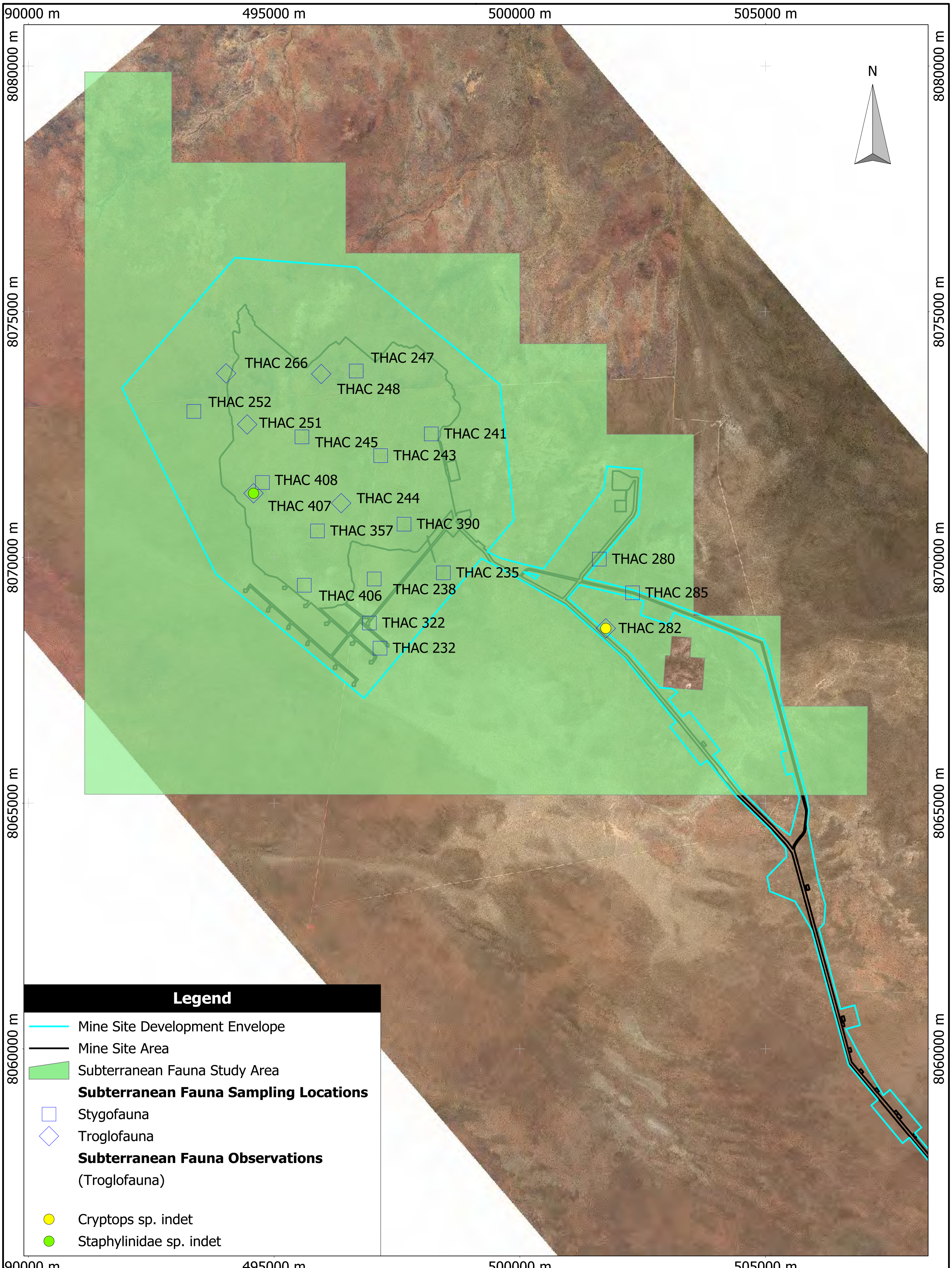
Should the Broome Sandstone Aquifer have secondary porosity developed in the form of fractures, and/or evidence of restricted calcareous sandstone geology with evidence of karst solution, then this could potentially provide habitat for stygofauna (Ecologia 2014a).

Results identified a low diversity and abundance of subterranean fauna with no stygofauna being recorded during the survey.

Similarly to stygofauna, there appears to be a low diversity and abundance of troglofauna present, this is potentially due to the habitat being dominated by Pindan sand plains which have little or no cavernous or vuggy habitat space. Only a single specimen (*Staphylinidae* sp. Indet) was recorded from bore THAC 407 within the Mine Site Development Envelope (Table 24 and Figure 33). As such, it is likely that habitat occurs within the Mine Site Development Envelope, but given the relatively continuous and expansive geology outside of this area and with no obvious dispersal barriers, this species is unlikely to have a restricted distribution and may occur within the extensive sandstone habitats in the ranges to the east and north of the project.

Table 24: Subterranean Fauna of the Mine Site Development Envelope

Site	Class	Family	Lowest Identification	Type	Inside/Outside Mine Site Development Envelope
THAC 282	Scolopendromorpha	Cryptopidae	*Cryptops* sp. indet	Troglofauna	Outside
THAC 407	Coleoptera	Staphylinidae	*Staphylinidae* sp. indet	Troglofauna	Inside



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Original Size: A4
Air Photo Date: 2015
Grid: Transverse Mercator
0 4 km

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Figure 33

Stygofauna and Troglofauna Sampling Locations and Observations

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4.2.11 Fire History

The Mine Site Development Envelope is located within the Mt Jowlaenga pastoral lease and is subject to regular burning by pastoralists, other stakeholders, and as a result of natural causes such as lightning strikes. The burning pattern within the Mine Site Development Envelope is reflective of controlled burning by land users to reduce the amount of combustible fuel in the area rather than sporadic and localised burning caused by wet season thunderstorms (Ecologia 2015b).

A 2006 EPA investigation into the frequency and intensity of fires in the Kimberley and other regions suggested that areas of the Dampier Peninsula have been historically burnt by Aboriginal people, pastoralists, authorities, travellers, accidents, and from natural sources (EPA 2006b). An assessment of the North Australian Fire Information database for the Mine Site Development Envelope indicates that there is an increasing trend in fire activity as shown in Figure 34, which may be impacting on flora and fauna in the region (EPA 2006b). Fire regimes in the Kimberley are very different from those once managed by Aboriginal people where historic burning was guided by seasons as well as cultural and hunting practices.

Number of Years Burnt Between 2000 and 2009 **Number of Years Burnt Between 2006 and 2015**

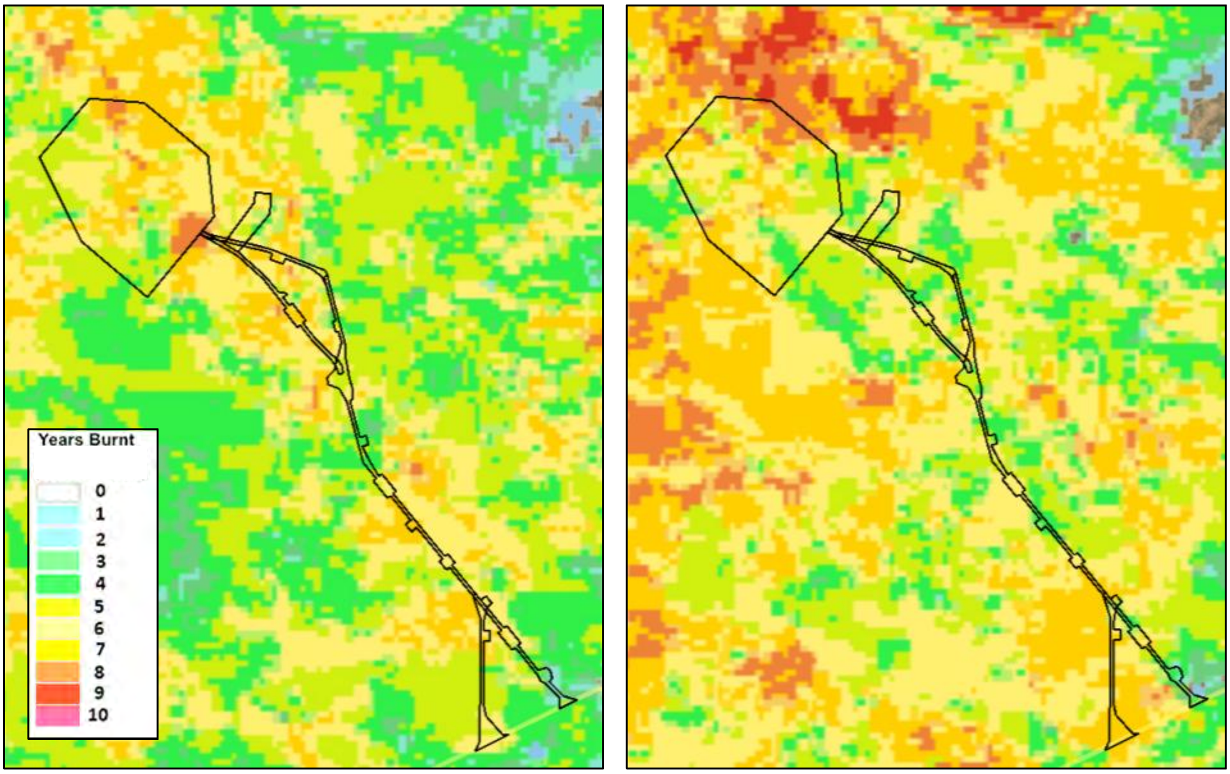

Figure 34: Mine Site Development Envelope Fire History

4.2.12 Land Use

The dominant land use within the subregion is native pastures, Unallocated Crown Land, and Crown reserves. The northern part of the project is located within the Mt Jowlaenga Pastoral Station and the southern part (Site Access Road) is located within the Yeeda Pastoral Station. Both pastoral stations are owned by Yeeda Australian Rangeland Meat Pty Ltd and produce beef products.

There are no nature reserves within the immediate vicinity of the Mine Site Development Envelope. The closest Nature Reserve is Coulomb Point Nature Reserve approximately 60 km to the northwest.

4.2.13 Heritage

4.2.13.1 Aboriginal Heritage

The broader west Kimberley is a region renowned for its rich diversity of Aboriginal heritage, and Aboriginal people have occupied the west Kimberley for at least 50,000 years. Aboriginal people in the west Kimberley maintain strong links with traditional culture and spirituality, and are active in caring for Aboriginal sites and places with Aboriginal heritage values.

Recently, the world's oldest ground edge axe fragment was found in an archaeological site near Fitzroy Crossing, dated between 44,000 and 49,000 years before present, and archaeological research in the area continues to push this date further into the past as new finds and older occupational deposits are discovered and reported.

Parts of the west Kimberley constitute a world class rock art precinct, famous for its richness, diversity, and unique assemblage of motifs. The rock art, generally found in the gorges and rocky outcrops of the river systems and plateaus, is amongst the oldest, and owing to the remoteness of most of the sites, best preserved in the world. Aboriginal rangers across the west Kimberley routinely care for and record the rock art sites, and work in collaboration with researchers.

The central, northern, and eastern areas of the west Kimberley are characterised by dramatic land formations and geological diversity, with many river carved gorges, rugged ranges, and plateaus. The Dampier Peninsula (the location of the project) is situated in the south west Kimberley, and is a region of relatively low topography, undulating pindan, and savannah. The Dampier Peninsula is adjacent to but not part of the rock art precinct, and has a comparative lack of suitable rock surfaces for creating and preserving painted rock art.

A search of the Mine Site Development Envelope and surrounds was undertaken using the Department of Aboriginal Affairs 'Aboriginal Heritage Inquiry System' to identify:

- Aboriginal Heritage Surveys over or near the Mine Site Development Envelope.
- Registered Heritage Places within or near the Mine Site Development Envelope.
- Other Heritage Places within or near the Mine Site Development Envelope.

No registered Aboriginal sites are located within the Mine Site Development Envelope. The nearest Heritage Place is the Nilli Bubbaca Well about 2 km from the intersection of the Site Access Road and Great Northern Highway, well away from any possible effect of the project.

Engagement with Traditional Owners and their representatives, the Kimberley Land Council (KLC) and KRED Enterprises' (KRED) subsidiary EHSIS (Environmental Heritage Social Impact Services), has been ongoing for five years. In 2011, Sheffield entered into a Native Title, Heritage Protection and Mineral Exploration Agreement, which has governed the undertaking of surveys and exploration work programs.

Aboriginal heritage surveys to support exploration activities have been undertaken in consultation with Traditional Owners annually since 2012 (Cox 2012; Ecologia 2012b; Biet Holmes 2013, 2014, 2015, 2016a, 2016b). In 2016, an Aboriginal heritage survey was carried out with Traditional Owners through KRED's subsidiary EHSIS (Biet Holmes 2016a). This survey focussed on the areas of the Mineral deposit footprint and Development Envelope, identifying and evaluating any potential impacts to Aboriginal heritage from the proposed project. The results of this survey have been used to inform project feasibility and detailed planning for the project and this PER.

All surveys have been undertaken using aerial (helicopter) and pedestrian (on ground) methods, utilising the existing knowledge of Traditional Owners and targeting on-ground investigations especially to locations considered to have most potential for Aboriginal sites to exist, such as rocky outcrops, water sources and areas of good ground surface visibility. Over the past five years these surveys have covered the entire Mine Site Development Envelope.

A summary of Aboriginal survey activity and outcomes is provided in Table 25. Aboriginal heritage survey coverage of the project area is shown on Figure 35.

Table 25: Summary of Aboriginal Heritage Surveys, Outcomes and Actions

Survey Season	Location	Native Title Group(s)	Outcomes Related to the Thunderbird Project
2012	E04/2083 Mt Jowlaenga Thunderbird Project area	Nyikina Mangala Bardi Jawi Nyul Nyul Nimanburr.	• Heritage survey and flora & fauna study completed with Traditional Owners • Avoidance buffers approved by Traditional Owners • Cultural heritage monitors employed • Exploration work program completed – approx.49km of drill track cleared and 164 drill holes completed
2013	E04/2081,2083-84,2159, 2191-94, 2171 Mt. Jowlaenga Thunderbird Project and surrounding area	Nyikina Mangala	• Heritage survey completed with Traditional Owners • Avoidance buffers approved by Traditional Owners • Cultural heritage monitors employed • Exploration work program completed – 64km of new drill tracks cleared and 281 drill holes completed
2014	E04/2081, 2083-84, 2159, 2171, 2191-94 Mt Jowlaenga Unclaimed Area Thunderbird Project and surrounding area	Nyikina Mangala	• Heritage survey completed with Traditional Owners • Avoidance buffers approved by Traditional Owners • Cultural heritage monitors employed • Exploration work program completed – approx.30km of drill tracks cleared and 142 drill holes completed
2015	E04/2083-84, 2159, 2171, 2192-94, 2349 Mt. Jowlaenga (now claimed) Thunderbird Project and surrounding area (including the Mine Site Development Envelope)	Bindunbur Nyikina Mangala Mt Jowlaenga Polygon#2 Claim Group	• Heritage surveys completed with Traditional Owners • Avoidance buffers approved by Traditional Owners • Cultural heritage monitors employed • Exploration work program completed – approx.8km of drill tracks cleared and 115 holes completed.
2016	MO4/459 within EO4/2083 Thunderbird Project proposed Mining Operations Area (including mineral deposit footprint and Mine Site Development Envelope)	Mt Jowlaenga Polygon#2 Claim Group	• First survey covered trenching and geotechnical drilling required for BFS works, second survey was completed to determine the ground available for mining purposes within the Mining Operations. Cultural heritage monitors employed during the BFS works. • Avoidance buffers around sites of significance were established and approved by Traditional Owners. • Survey clearance was to assist with heritage understanding within the Public Environmental Review.

The outcomes of the surveys were:

- The project area has been extensively and comprehensively surveyed, and all areas considered sensitive to Aboriginal cultural values in the Mine Site Development Envelope and surrounds have been covered.
- Aboriginal sites and areas of Aboriginal cultural value have been identified and mapped.
- Avoidance buffer zones have been determined by Native Title claimants.

Further detail regarding the results of the Aboriginal heritage surveys are subject to a confidentiality agreement between Sheffield and the Native Title claimants at the claimants' request. As such, Sheffield is unable to disclose details or the location of the Aboriginal heritage sites for public review.

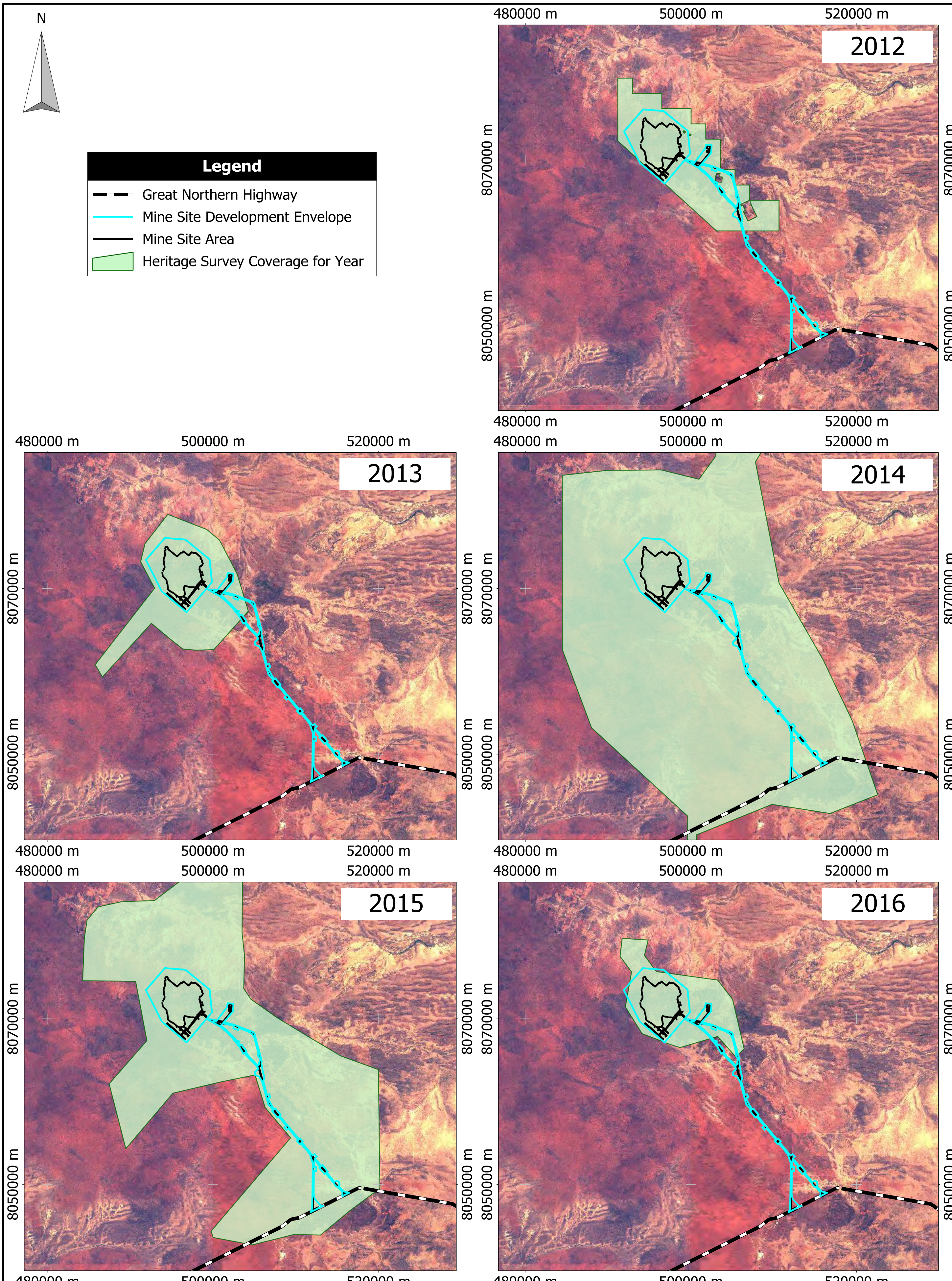

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Image: Copernicus Sentinel Data 2016
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Thunderbird Mineral Sands Project

Figure 35

Aboriginal Heritage Survey Coverage of Mine Site Development Envelope

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W:\Sheffield Resources\PER\Drawings\PER Map.map 21/12/2016 F35 Heritage Survey Areas A4P

4.2.13.2 Native Title

The Thunderbird Mineral Sands Project tenure sits within three distinct areas:

- Mt Jowlaenga #2 People Native Title Determination Application (National Native Title Tribunal reference number WC2014/005).
- Nyikina Mangala Consent Determination Area (National Native Title Tribunal Reference Number WCD2014/003). The southern sections of the Site Access Road are located within this area.
- An area between the two which is unclaimed.

Figure 36 shows Native Title Applications over and surrounding the Mine Site Development Envelope.

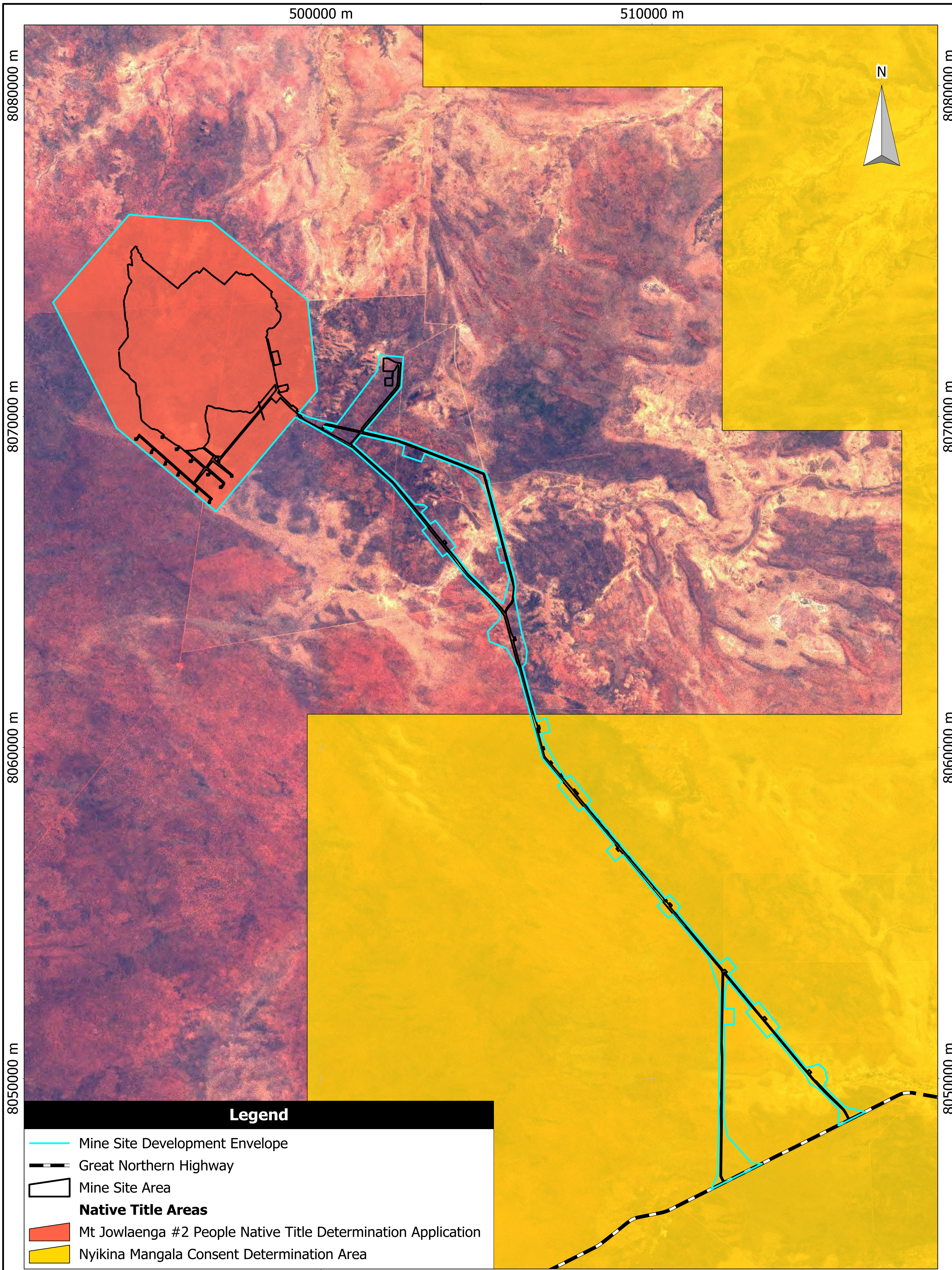
Sheffield is working in close consultation with Traditional Owners to reach a Mining Agreement for the project. Details of the consultations are necessarily subject to a confidentiality agreement and therefore cannot be released for public review.

4.2.13.3 European Heritage

A search of the following databases was carried out to identify registered, non Aboriginal heritage sites within or near the Mine Site Development Envelope:

- *EPBC Act* Protected Matter (Search Tool).
- Commonwealth Heritage List (CHL).
- World heritage List (WHL).
- State heritage Council Western Australia Register of Heritage Places.
- Shire of Derby/West Kimberley Municipal Register of Heritage Places.
- Shire of Broome Municipal Inventory of Heritage Places

No heritage places were identified within the Mine Site Development Envelope.



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Original Size: A4
Image: Copernicus Sentinel Data 2016
Grid: Australia MGA94 (51)

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Figure 36

Native Title Applications - Mine Site Development Envelope

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4.2.14 Air Quality

There are no significant emissions sources in the vicinity of the Mine Site Development Envelope and due to the remote location, it is presumed that air quality will typically be very good. The main contributors to air quality, specifically particulate levels are ambient wind-borne dust (from dust storms, cattle, and vehicle movements) and smoke from dry season bush fires. Background and cumulative emissions from other industrial activities are expected to be negligible and naturally occurring background particulate concentrations are expected to be minor.

During project design, in order to be conservative, the average ambient dust concentrations found in northwest Western Australia have been used to ensure the worst-case scenario is considered (40 $\mu g/m^3$ for TSP, 20 $\mu g/m^3$ for PM_{10} and 7 $\mu g/m^3$ for $PM_{2.5}$). These concentrations are based on a number of studies of ambient monitoring in the Kimberley and Pilbara areas, which both experience a higher level of activity than the Mine Site Development Envelope and as such are seen to be a conservative choice in lieu of local data (Atmospheric Solutions 2016a; Appendix 12).

4.2.15 Light

Given the remote location of the Mine Site Development Envelope, background artificial light levels are very low and would be typical of most rural sites where pastoral activities occur, varying with the extent of vehicle traffic, machinery operation, and general activity at any given time.

4.2.16 Noise

A noise assessment was undertaken for the Mine Site Development Envelope (WSP Parsons Brinckerhoff 2016b; Appendix 13).

4.2.16.1 Background Noise Levels

No background noise studies specific to the Mine Site Development Envelope have been undertaken, however, given the remote location, background noise levels are expected to be very low and would be typical of most rural sites where pastoral activities occur. Noise would generally be from non-anthropogenic sources such as wind-induced foliage noise, and insect, bat, and bird noise.

Table 26 details the low attended noise measurements measured at the start of the Mt Jowlaenga road in May 2016, approximately 27 km from Mine Site infrastructure.

Table 26: Mt Jowlaenga Site Access Road Attended Noise Measurement

Time	L_{A90} dB	L_{A10} dB	L_{Amax} dB	Comments
10:55 am	23	26	30	Paused for traffic passing by on Great Northern Highway. Insect and wind noise in foliage dominant
11:05 am	27	50	62	Not paused. Traffic, insect and wind noise in foliage dominant

A literature review was carried out to identify studies of background noise levels in the Kimberley, with the most appropriate identified as the *Browse Liquefied Natural Gas Precinct – Strategic Assessment Report Part 4: Environmental Assessment – Terrestrial* (DSD 2010). Noise levels from this study are outlined in Table 27.

Table 27: Background Noise Levels Within North Western Australia

Measurement Site	L_{A90} Sound Pressure Level d_{BA}[1]		
Northern Carnarvon Basin	24	33[2]	29
Burrup Peninsula	25 - 30	25 - 30	25 - 30

1 Lowest 10th percentile of L_{A90}

2 Noise Levels influenced by people on the beach

Additionally, based on similar inland location within the Pilbara, Western Australia, noise levels could be expected to be within those listed in Table 28.

Table 28: Expected Existing Noise Levels

Sound Pressure Level dBA	Day (0700-1900)	Evening (1900 – 2200)	Night (2200 – 0700)
L_{10}	39 - 45	34 – 45	37 - 42
L_{90}*	22 - 30	27 - 34	17 - 32

** Lowest 10th percentile of L_{A90}*

4.2.16.2 Nearest Sensitive Receptors

The nearest residence, Mt Jowlaenga Station Homestead (currently uninhabited), is located approximately 2 km from the Mine Site Development Envelope. The identified nearest potential sensitive human receivers (and their distance from the Mine Site Development Envelope) are:

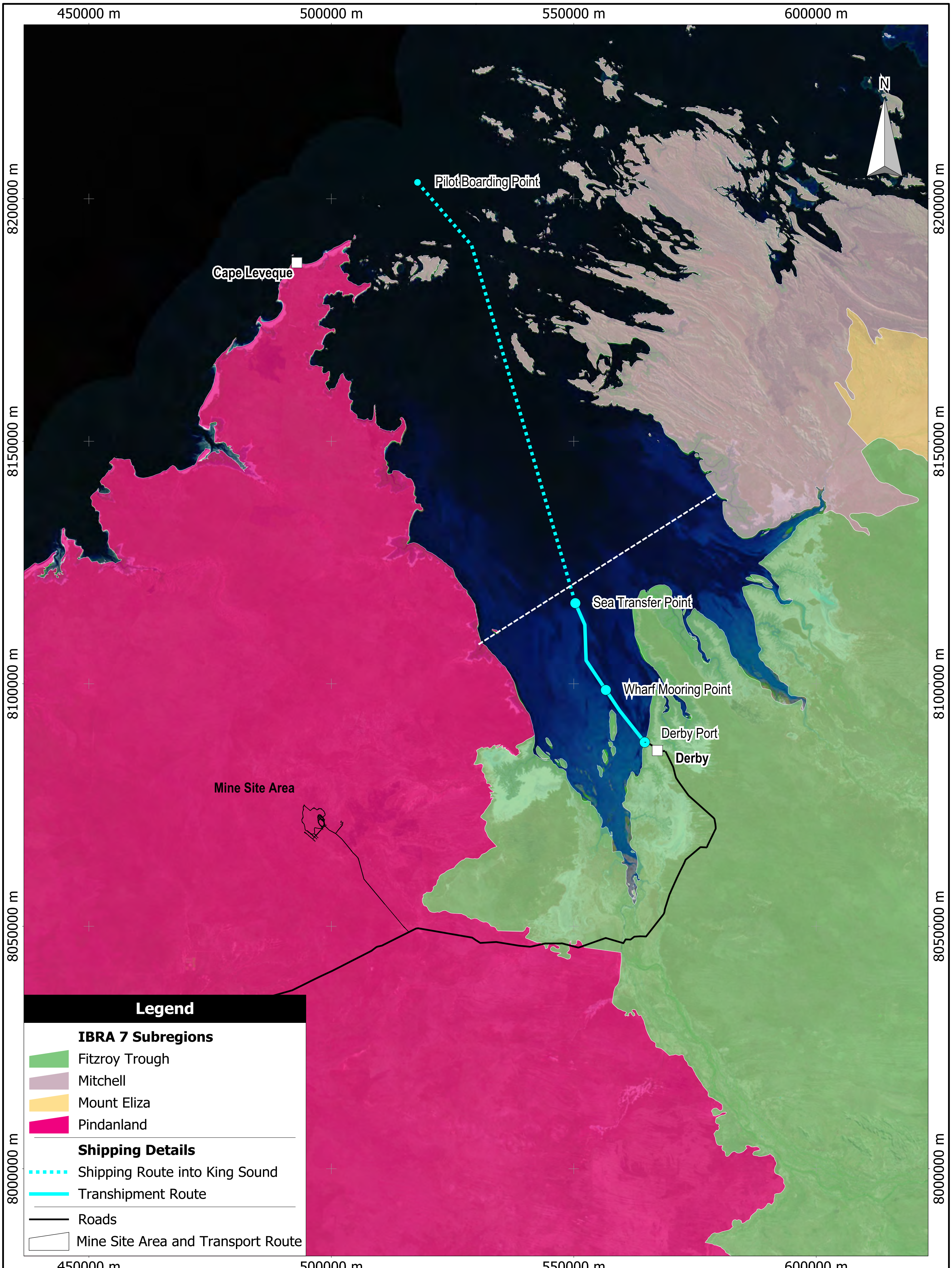
- Mine Site accommodation village - 5 km.
- Nillibubbica designated rest area, Great Northern Highway - 27 km.
- Bidan (formerly known as Bedanburu) Aboriginal Community - 28 km.
- Yeeda Outstation, Mt Jowlaenga Road - 28 km.

4.3 DERBY PORT DEVELOPMENT ENVELOPE

This section describes information regarding the physical, biological and socio-economic characteristics of the proposed Derby Port Development Envelope (Figure 15). This includes all information gathered during physical and biological surveys conducted for the project for this area. The product transport route from the Mine Site to Derby Port is shown on Figure 14, and the transhipment route is shown on Figure 16.

4.3.1 Regional Setting

The townsite of Derby is located on a peninsula of slightly elevated Pindan soils that sits above the surrounding tidal mud flats within the Dampierland bioregion and Fitzroy Trough subregion, as defined by the IBRA classification system. Derby Port is located on the edge of King Sound, approximately 2 km northwest of the townsite and is accessed via a narrow manmade causeway (Jetty Road). The location of Derby Port and IBRA regions are shown on Figure 37.



Scale: 1:1000000 Original Size: A4 Image: Geoscience Australia LS7 2007 Grid: MGA94(51) 0 20 km	Sheffield Resources Limited Thunderbird Mineral Sands Project	**Figure 37** **Interim Biogeographic Regionalisation for Australia (IBRA 7) for Transport Route**	Martinick Bosch Sell Pty Ltd 4 Cook St West Perth WA 6005 Ph: (08) 9226 3166 Fax: (08) 9226 3177 info@mbsenvironmental.com.au www.mbsenvironmental.com.au MBS ENVIRONMENTAL

4.3.2 Port History

The town of Derby was declared in 1883 and was established to service the pastoral industry. It has since expanded, along with the West Kimberley region, to service the growing number of industries including tourism, mining, oil, and natural gas (Derby Tourism 2016).

Historically, Derby Port comprised a wooden T-shaped jetty structure located at the northern end of the present steel and concrete wharf, and was first constructed in 1885 to facilitate sheep export. It was linked to the town of Derby by a horse-drawn tramway, crossing the mud flats via a causeway where the present day Jetty Road is located. The wharf was upgraded in 1964 to steel and concrete and serviced sheep and cattle export, as well as the intermittent export of mining products. Derby Port was officially closed to commercial shipping in 1982 and the wharf was closed by the Department of Transport in 1994.

Derby Port was reopened in 1997 as a lead and zinc export facility which operated until 2008 when the Lennard Shelf Lead and Zinc Operations closed. While it was operational, lead and zinc concentrate was delivered to the port via road trains which tipped into a purpose-built storage facility adjacent to the wharf, which has now been decommissioned. The storage facility used a hopper system fed by front-end-loaders to transport lead and zinc concentrate to the end of the wharf and to an awaiting shallow transhipment vessel. Transhipment vessels were loaded at high tide via a conveyor belt and ship-loading infrastructure (which remains in place). The loaded vessels then transported lead and zinc concentrates from the wharf to the sea transfer point located near Point Torment, where they were then transferred onto a handymax vessel for export.

The location of the storage facility was determined to be a contaminated site by Department of Environment Regulation (DER). The site was subsequently remediated by the previous lessee in accordance with plans approved by DER. Further details on the site's contaminated site status are provided in Section 4.3.7.1.

Since closure of the lead and zinc export operations, Derby Port has been used to fuel and load transhipment vessels that supply iron ore operations at Koolan and Cockatoo Islands, and to support aquaculture and tourism ventures. The port area is also used by the public for fishing, boat launching, and sightseeing, as it is the only access point to coastal waters off Derby; however the public can only access parts of the wharf. Derby Port is managed by the Shire of Derby/West Kimberley under a lease from the Department of Transport.

4.3.3 Derby Society and Population

The Shire of Derby/West Kimberley has a population of approximately 5,940 people, of which 3,380 reside within the town of Derby, and a further 2,560 reside in communities and regional areas associated with Derby. As of the 2011 Census, Derby has an unemployment rate of 5.0%, slightly higher than the Western Australian rate (4.7%) and lower than the Australian rate (5.6%). The main occupation in Derby is 'Professional' at 21% followed by 'Community and Personal Service Workers', 'Labourers', 'Technicians and Trades Workers', and 'Clerical and Administrative Workers' (between 13 to 15% each) (ABS 2016).

Within the town of Derby, a number of potentially sensitive land uses are located along or just off Loch Street, which leads to Derby Port (Figure 38), including:

- Holy Rosary Catholic Primary School.
- Holy Rosary Catholic Church.
- Derby District High School.
- The Rural Clinical School of Western Australia.
- Derby Hospital.
- The Scallywags Child Care Centre (approximately 1 km from Loch Street and Derby Highway).

4.3.4 Climate

The climate at Derby is very similar to that at the Mine Site Development Envelope (Section 4.2.2), comprising a tropical monsoon climate with a winter dry season and a summer wet season. The mean annual rainfall for Derby is 691.0 mm. Mean monthly rainfall is highest in February (199.6 mm) and lowest in August (0.8 mm). Rainfall intensity may be high (e.g. the highest 24 hour rainfall recorded at Derby was 418 mm in January 1917), and is mostly associated with cyclonic activity. Average monthly minimum temperatures are lowest in July (14.7°C) and average monthly maximum temperatures are highest in November (38.1°C; BoM 2016b). Prevailing winds are mainly strong easterly to southeasterly in the morning and mainly southeasterly to northwesterly in the afternoon. Cyclone risk with respect to wind is much lower than Broome and coastal Pilbara towns due to fewer cyclones and fewer severe cyclones impacting on the area. Section 4.2.2 details cyclone risk within respect to the Mine Site Development Envelope, and is also relevant for the Derby Port Development Envelope.

4.3.5 Topography

The topography in the Derby region is gently undulating. The main features are the Grant Range and isolated erosion scarps, including the Sisters Plateau, Erskine Range in the east and the Reeves Hill – Dampier Hill Scarp in the west. The terrain is generally low lying in the north and rises to approximately 150 m AHD southwest and southeast of King Sound. Wide-spaced, easterly trending longitudinal sand dunes occur throughout the area. The principal drainage systems for Derby include the Fitzroy, May, Meda, and Fraser Rivers, as well as the Alexander and Hawkstone Creeks which are fed by groundwater (DoW 2008).

Derby Port is situated on a narrow stabilised mangrove mudflat system that lies in a north to south direction approximately 2 km from the town of Derby. The mangrove area is surrounded by the tidal mudflats of King Sound to the east and west, with a narrow causeway linking the port to the town across the eastern mudflats. The causeway and port were reclaimed from the mudflats by use of local rock and soil material sourced from the Derby hinterland. Elevation is very low and flat, with most of the stabilised land no more than a few metres above the tidal mudflats (MBS 2009).

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Original Size: A4
Image: Landgate Locate WA
Grid: Australia MGA94 (51)

0 500 m

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Figure 38

Sensitive Land Uses Near Derby Port Development Envelope and Transport Route

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4.3.6 Geology and Soils

4.3.6.1 Geology

The geology of the catchment area draining into King Sound is extremely diverse. The southern areas overlay the Canning Basin, which is a sedimentary sequence of rocks extending from the early Ordovician to the Cretaceous and overlain by recent alluvial and aeolian sediments (MBS 2009).

To the north of the Canning Basin, the geology consists of diverse igneous and metamorphosed sedimentary rocks of Proterozoic to Archaean age (Halls Creek Orogen). Between these two geological provinces is the Lennard Shelf, which is a Devonian system of reef carbonates, limestones and sandstones. The karst limestone geology is commonly associated with zones of lead and zinc sulfides, several of which have been mined. These included mines operated by Western Metals and Lennard Shelf, namely the Cadjebut, Pillara, Goongewa, and Kapok mines (MBS 2009).

4.3.6.2 Soils of the Derby Region

The soils of the Derby region belong to the Dampier Sandplain zone, comprising sandplains, dunes and coastal mudflats overlying the sedimentary rocks of the Canning Basin. Locally, the dunes and sandplains belong to the Yeeda system. The soils are referred to as 'Pindan'. They are usually red-brown sands to sandy earths and are believed to be of aeolian origin. Soils from the dunes tend to have a higher sand content than those of the associated swales (MBS 2009).

4.3.6.3 Intertidal Mudflats

The geomorphology of the tidal mudflats of King Sound has been described by Semeniuk (1982). Erosion over the past 5,000 years has been the dominant shore-forming process, resulting in the erosion of coastal sediments deposited from the major river systems during the Holocene (up to 10,000 years before the present; Semeniuk 1982).

The sub-tidal areas between Derby Port and the townsite comprise the following landforms:

- Tidal mudflats, which are partially or fully exposed at low tide.
- Mangal flats, which are stabilised by mangroves and incised by numerous creeks.
- Saline mudflats, which are devoid of vegetation and only inundated following high rainfall or at spring high tide.
- Samphire flats, which are vegetated with salt tolerant (halophytic) plants.
- Red sand dunes, as described in Section 4.3.6.2.

The stratigraphy of the natural soil sequence near Derby Port from the surface downwards is:

- A surface horizon of bio-turbated brown mud within the root zone of the mangroves.
- Christine Point Clay, which is a slate grey coloured clay horizon containing fossil mangrove stumps.
- Mowanjum Sand, similar to the red Pindan soil of the West Kimberley region.
- Airport Creek Formation, a semi-lithified and nodular cemented deposit of interlayed sand and mud.

The physical presence of the wharf structure has resulted in substantial deposition of coarse sand sediments immediately below and to the north and south of the wharf. These sand banks are exposed at low tide (MBS 2009).

4.3.6.4 Reclaimed Land

The causeway across the mudflats between the port and town of Derby was constructed from local rock and soil sourced from the Derby hinterland. Much of the soil at the proposed storage facility area consists of fill material, typically Pindan soil sourced from the mainland over the Port's 120 year history. A large proportion of this material was imported and placed in 1997 as part of construction works for the former lead and zinc concentrate storage facility.

4.3.7 Derby Storage Facility Baseline Contamination Assessment

4.3.7.1 Contaminated Site History

The Derby Port area has a long history of contaminated sites due to the former storage and export of lead and zinc concentrates from the Lenard Shelf Lead and Zinc Operations.

The Contaminated Sites Branch of DER carried out inspections at the port in June and August 2007. A Notice of Classification of a Known or Suspected Contaminated Site was subsequently issued by DER on 12 September 2008 to the former sublessees, Lennard Shelf Pty Ltd. The category of site classification was 'Possibly Contaminated - Investigation Required' on the basis of the identification of lead and zinc in concentrations above the Ecological Investigation Levels (EILs) for soil.

The site was investigated and a closure plan prepared in March 2009 (MBS 2009). This included a site management plan for remediation of contaminated areas. The closure plan was assessed as satisfactory by DER in a letter dated 7 April 2009 and the site was subsequently closed and remediated during 2010 to 2011 by Rey Resources Limited.

Validation sampling and reporting was undertaken at the site in 2012. While some residual lead and zinc concentrations exceeded the respective EILs but remained within discrete locations across the site, the risk to the surrounding environment was assessed as low. The site was deemed to be remediated to a level appropriate for its intended land use (industrial/commercial), with minimal risk to the surrounding environment as a result of residual soil contamination (MBS 2012). Due to the absence of any groundwater data beneath the site, the site remains classified as 'Possibly Contaminated – Investigation Required'.

4.3.7.2 2016 Baseline Contamination Assessment

Given the history of the Port area, a detailed inspection was undertaken by MBS Environmental senior geochemists during June 2016. This included a review of previous site history and contamination assessment reports, and a site visit to collect representative samples of soils, basement clays, and marine sediment. These samples were analysed for potential contaminants of concern and potential presence of acid sulfate soils (ASS). A summary of the findings are reported below, with the full report provided in Appendix 14.

Residual low level zinc concentrations remain in some of the imported Pindan soils across the Port area, however these levels are significantly below industrial health investigation levels (HILs). The maximum concentration of zinc (360 mg/kg^{-1}) was equal to the site specific calculated National Environmental Protection Measure (NEPM) 2013 added contaminant level for this sandy soil type and would be at or below the EIL for the site depending on background concentrations. This is consistent with the previous site history and validation report (MBS 2012).

Concentrations of lead were correlated with zinc and were consistent with previous site use of exporting lead/zinc sulfide mineral concentrates, however no samples were found to exceed the industrial EILs or HILs for lead.

Examination of subsoil basement clays in accessible parts of the Port area indicated a slight presence of sulfidic material in an otherwise alkaline clay matrix, which was insufficient for classification as ASS materials. Further samples for assessment were taken from the eastern mudflats as they are considered to represent the same underlying heavy clay/silt; these were also classified as not being ASS.

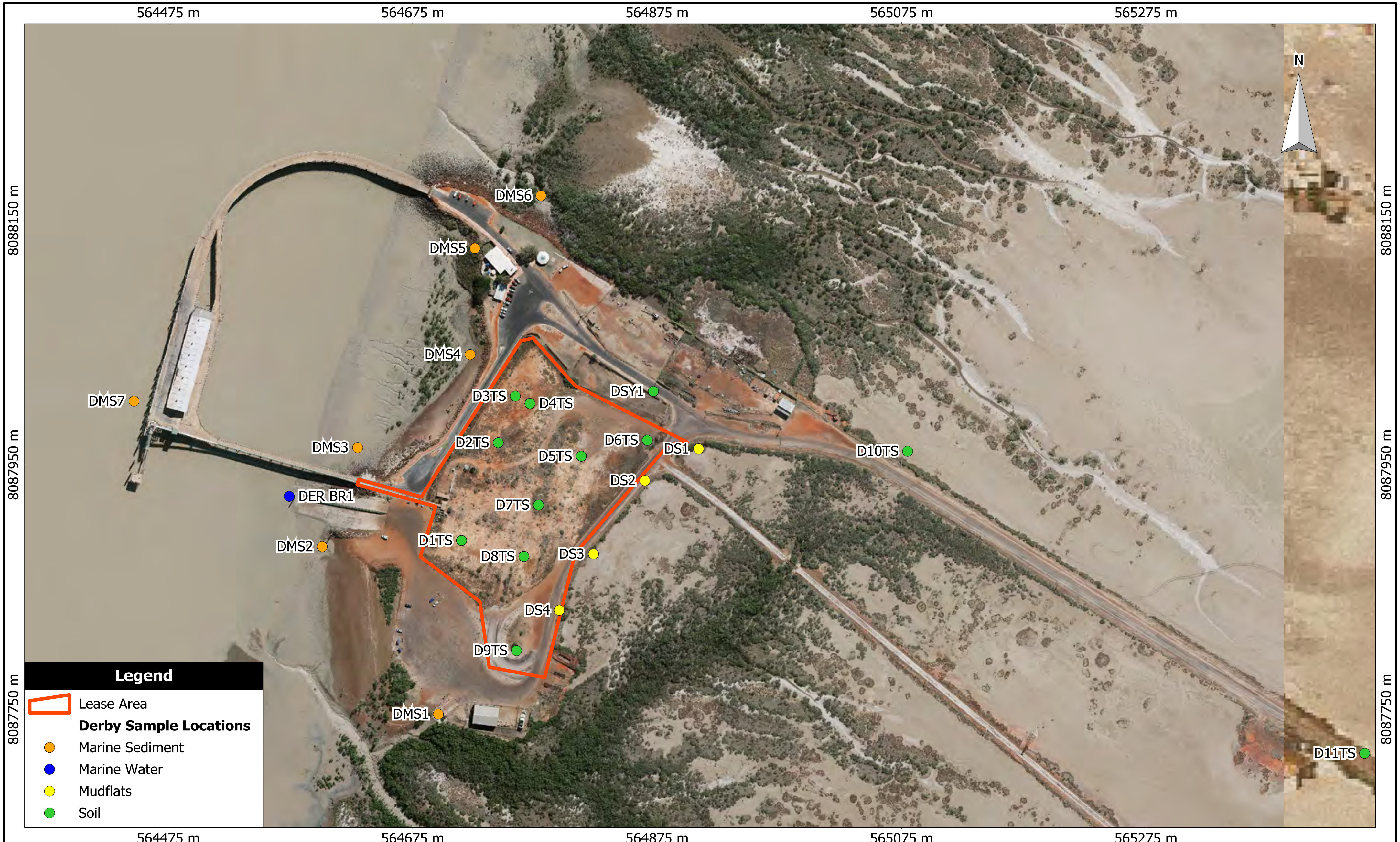
Samples of the mudflats east of the lease area indicate some elevation of zinc and lead above background levels adjacent to the culverts, and particularly at location DS4 (Figure 39; 360 mg/kg zinc, 95 mg/kg lead). These elevated results were attributed to previous site history and road run off. The zinc concentration is above the lower interim sediment quality guideline (ISQG-Low) of 200 mg/kg, but below the calculated NEPM 2013 added contaminant level of 1,200 mg/kg (based on an assigned land use of recreational/public open space).

All samples of clay/silt sediment including inshore marine, mudflats, and basement clays were in range of 22 to 31 mg/kg for nickel, which marginally exceeds the ISQG-Low of 21 mg/kg. This strongly suggests a natural enrichment of nickel at this concentration in the estuarine silt/clay from the area.

Copper concentrations in marine sediment samples DMS1 (90 mg/kg) and DMS2 (66 mg/kg) were above the ISQG-Low of 65 mg/kg, and significantly higher than other clay/silt based samples (23 to 35 mg/kg). Both these locations are used for boat launching and marginally elevated copper levels may be the result of copper anti-fouling paint from boat hulls.

No ISQG exceedances for arsenic, cadmium, chromium, silver or mercury were recorded. Selenium concentrations were all below the level of reporting. Uranium concentrations in silt/clay dominant sediment samples were consistently between 2.4 to 5.2 mg/kg, which similar to the average crustal abundance (2.7 mg/kg). Samples of sandier substrate at DS1 and DMS7 had lower concentrations (0.81 and 0.75 mg/kg respectively).

Overall the assessment of all samples taken in and adjacent to the proposed Derby product storage facility for analysis of metals and metalloids indicated concentrations considered either representative of the region or reflective of a Port facility with prior history of (in particular) lead and zinc exports. Further assessment of the soils and sediments within the lease area which may be disturbed in minor volumes by construction of a product storage facility indicated no significant risk of ASS. No significant disturbance of marine sediment and hence opportunity for oxidation and metals/metalloids release is expected as the wharf is already constructed.



Scale: 1:4000
Original Size: A4
Air Photo: Landgate 2015
Grid: MGA94(51)

0 100 m

Figure 39

Baseline Contamination Assessment Sampling Locations

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W:\Sheffield Resources\PER\Drawings\Derby BCA-PER.map 21/12/2016 F39 Baseline Sampling Layout

4.3.8 Hydrology and Hydrogeology

4.3.8.1 Hydrology

Derby Port and the proposed Product Storage Facility are situated on a raised section of reclaimed land. King Sound is located to the immediate northwest and its associated saline mudflats are situated to the immediate east. Stormwater runoff from the reclaimed section of land drains directly into either King Sound or the mudflats. Inundation of the mudflats is rare, but can occur following a high rainfall event or during a spring high tide (MBS 2009). Within the proposed Product Storage Facility, stormwater generally reports to the northwestern corner and is managed by an existing earth v-drain that runs along the northwestern perimeter. This drain ultimately reports to King Sound.

4.3.8.2 Subsurface Water Quality and Levels

Subsurface water underlying the proposed storage facility is controlled by tidal movements (Section 4.3.11.2), consisting predominantly of brackish water becoming more saline with depth as levels approach the seawater interface. The position of the site, on the western edge of the tidal mudflats, and the very low elevation results in saturated subsurface conditions at depths greater than 2 m below the ground surface, with the water table expected to occur slightly above mean sea level.

4.3.8.3 Hydrogeology

Derby is located on the northern part of the Canning Basin that comprises Phanerozoic sediments of approximately 8,000 m thickness at the Derby Peninsula (DoW 2008).

The stratigraphic sequence at Derby in order of increasing age is:

- Quaternary sediments.
- Meda Formation.
- Wallal Sandstone.
- Munkayarra Shale.
- Erskine Sandstone.
- Blina Shale.
- Liveringa Group.
- Nookanbah Formation.
- Poole Sandstone.
- Grant Group.

The principal regional aquifers with potential for potable water supply are the Wallal Sandstone and the Erskine Sandstone. The Liveringa Group, Poole Sandstone, and Grant Group also contain groundwater at depth. With the exception of the Liveringa Group in the deep Derby Town Bore (600 to 700 m), these aquifers have been exploited only in areas where they occur at shallow depths (DoW 2008).

An unconfined aquifer with a maximum saturated thickness of 60 m is located in the Derby area, comprising of the Quaternary sediments, the Meda Formation, and the Wallal Sandstone (DoW 2008). The Wallal Sandstone aquifer receives recharge via direct rainfall infiltration. Groundwater flow in the aquifer is westerly toward King Sound.

The Erskine Sandstone is a multilayered aquifer with shale interbeds, and is generally confined by the overlying Munkayarra Shale. Groundwater flow in the aquifer is generally northerly toward the May River, however near

Derby the Erskine Sandstone is in direct hydraulic connection with the Wallal Sandstone as the confining Munkayarra Shale is absent (DoW 2008).

Groundwater in the vicinity of the proposed storage facility has no beneficial water use.

4.3.9 Land Use

The Derby town includes a number of areas zoned for a variety of different land uses including commercial, industrial, residential, and various other public and recreational land uses. The Port area has been zoned for 'port industry'.

There are no other industrial or agricultural land uses in the immediate vicinity of the Port. The closest operating commercial enterprises are the privately run Wharf Cafe located approximately 150 m north of the Derby Port Development Envelope, and an industrial laydown area located approximately 100 m northeast of the Derby Port Development Envelope, the latter of which was previously used for the former Cockatoo and Koolan Island iron ore operations (MBS 2009). A portion of the wharf is used for storage and export of fish produce (barramundi). A non-operating mud crab enterprise is located approximately 100 m northeast of Derby Port.

The wharf area is a popular recreational area for local residents and tourists, and a public boat ramp is located to the immediate west of the proposed storage facility. The most popular activities include fishing (including mud crabs) and passive recreation. Several professional fishermen are licensed to catch barramundi and other species (Fletcher and Santoro, 2015). Existing regional marine use is detailed in Section 4.3.12.

4.3.10 Terrestrial Flora and Fauna

4.3.10.1 Vegetation

The Derby Port Development Envelope is located in a previously disturbed industrial area, with very limited native vegetation or fauna habitat present. The site of the proposed storage facility was previously used for the storage of lead and zinc metal concentrates prior to export. The site has been the subject of contaminated sites investigations and remediation, refer to Section 4.3.7.1.

4.3.10.2 Conservation Significant Fauna

A search of the following databases was undertaken over the Derby Port Development Envelope and transhipment vessel transport route to determine conservation significant coastal fauna species that may occur in the area:

- *WC Act* & DPaW Threatened and Priority Fauna Database using a polygon shown in Appendix 15.
- *EPBC Act* Protected Matters Search including 0.5 km buffer as shown in Appendix 16.
- Naturemap database (DPaW 2016a).

In addition to the species found in these database searches, other species of conservation significance were identified from searches of the scientific literature. Most of the species identified during the database searches are marine and migratory fauna and these are discussed in Section 4.3.14.2.

Twelve terrestrial bird species and two terrestrial mammal species were identified in the searches as potentially occurring within the Derby Port Development Envelope. Of these, eight species are listed as Threatened under the *EPBC Act*, Vulnerable or Endangered under the *WC Act*, or listed as a Priority species by DPaW. These species have been termed 'conservation significant' species and are shown in Table 29.

Suitable habitat for most of these species is limited in the Derby Port Development Envelope, indicating most of these species are unlikely to be residents or regular visitors in the area.

Table 29: Conservation Significant Species Potentially Occurring Within Derby Port Development Envelope

Species	Conservation Status			Habitat	Likelihood of Occurrence	Recorded
Common Name	EPBC Act	WC Act	DPaW			
Birds						
Gouldian Finch *Erythrura gouldiae*	E	-	P4	Rocky hills with smooth-barked gums within 2 km to 4 km of permanent freshwater (O'Malley 2006).	Medium – Possible foraging habitat	No
Grey Falcon *Falco hypoleucos*	-	T(V)	-	Inland drainage systems with an average annual rainfall <500 mm. Prefers timbered lowland plains (especially those that are acacia-dominated) which are interspersed with tree-lined watercourses (Johnstone and Storr 1998).	Low – lack of suitable habitat	No
Letter-winged Kite *Elanus scriptus*	-	-	P4	Extreme population fluctuations linked to rat populations. In years of rat plague, the kite may be found around many parts of the country. Normal range is the Coopers Creek drainage system (Birdlife 2016).	High – only in rat plague years	Yes (Birdlife 2016)
Princess Parrot, Alexandra's Parrot *Polytelis alexandrae*	V	-	P4	Occurs in swales between sand dunes and sand flats in the arid zone of western and central Australia; open savanna woodlands and shrublands. (Garnett and Crowley 2000).	Low – lack of suitable habitat	No
Purple-crowned Fairy-wren *Malurus coronatus subsp. coronatus*	E	T(E)	-	Only found in northern Australia. Inhabits dense, riparian vegetation in the wet-dry tropics of Western Australia and the Northern Territory. Mangrove habitat not utilised. Now locally extinct in the lower Fitzroy River catchment (Rowley 1993). Does not utilise mangrove habitats (DoE 2016).	Low – locally extinct	No
Red Goshawk *Erythrotriorchis radiatus*	V	T(V)	-	Coastal and sub-coastal tall, open forests and along edges of rainforests. Infrequently immature birds use mangroves. Nests in trees >20 m (Garnett et al. 2011; DoE 2016).	Medium – Possibly immature birds	No
Mammals						
Northern Quoll *Dasyurus hallucatus*	E	T(E)	-	Rocky habitats that provide for den sites. Tidally flooded mangrove areas are not used (DoE 2016).	Low – rocky habitats not present on the reclaimed land at the Port	No
Water Mouse, False Water Rat *Xeromys myoides*	V	-	-	Mangroves and associated marshlands, sedgelands, clay pans, heathlands and freshwater wetlands (DoE 2016).	Medium – possibly present in low numbers	No

Legend: T – Threatened; V – Vulnerable; E – Endangered; P – Priority list; '-' No classification

4.3.11 Physical Marine Environment

Derby is located at the head of King Sound, which is a large embayment (approximately 130 km long and 40 km wide). The Buccaneer Archipelago lies between the opening of King Sound and the open ocean. Bulk product export is proposed to occur from Derby Port, via transhipment to a sea transfer point near Point Torment, and then across King Sound to the open ocean.

The open water area of King Sound is approximately 2,325 km^2 and the intertidal salt and mud flats occupy 209 km^2. Supra-tidal salt flats occupy 590 km^2 and are inundated at the highest spring tides in summer. Mangroves occupy an area of 165 km^2 between the intertidal and supra-tidal zones (Wolanski and Spagnol 2003). The Fitzroy River, one of Australia's largest river systems, flows into King Sound and affects the water quality in King Sound.

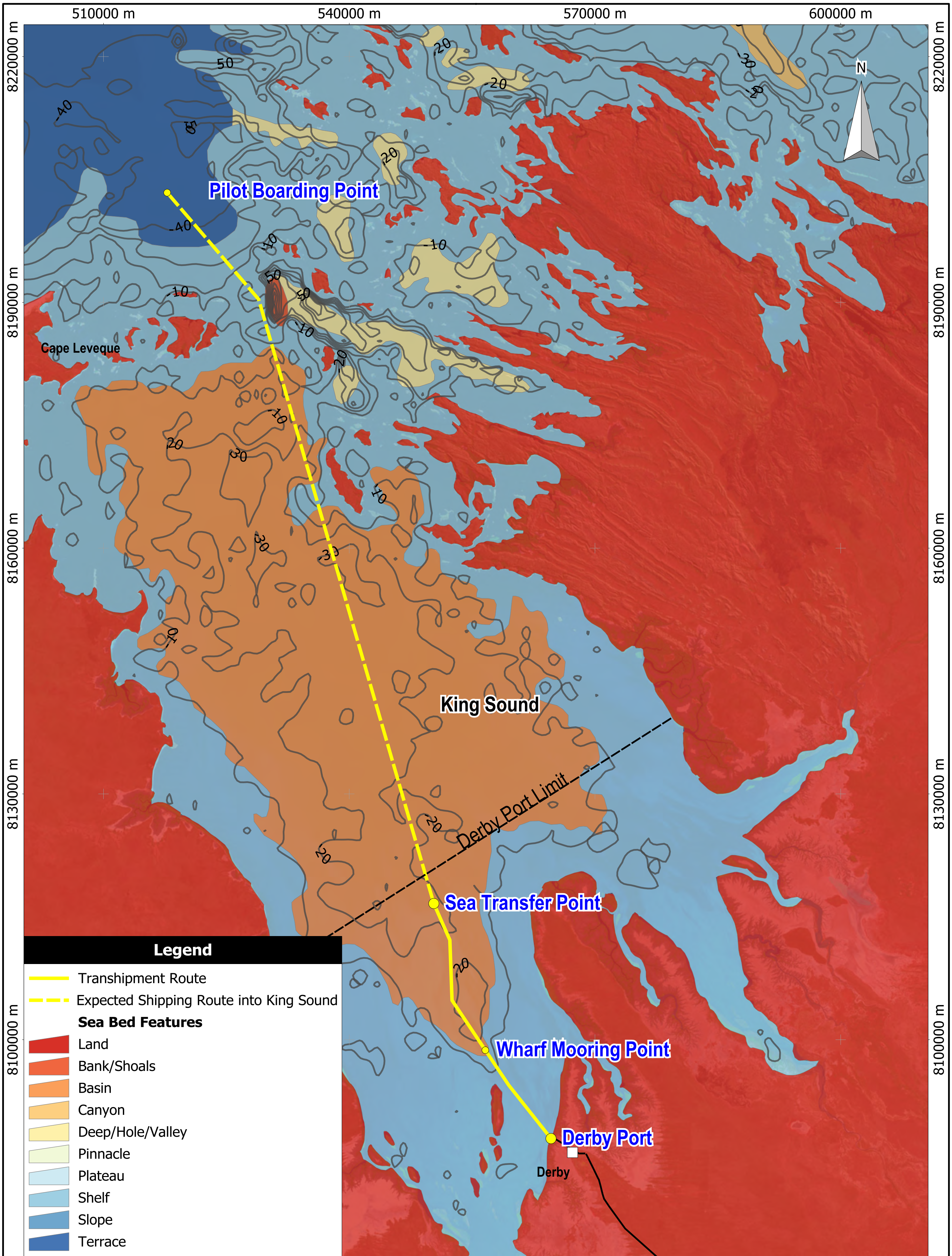
In the dry season, the water of King Sound is vertically well mixed in both temperature and salinity. High evaporation levels cause the maximum salinity to occur in the upper reaches of the Sound (Wolanski and Spagnol 2003).

The existing regional marine environment of King Sound has been characterised in the following sub sections.

4.3.11.1 Bathymetry

Within the Port Limits, King Sound is relatively shallow at around 15 m deep at the wharf mooring zone and around 20 m deep at the sea transfer point (measured at the lowest astronomical tide). From Derby Wharf to the wharf mooring zone, the sea bed consists of a gently sloping plateau, with the seafloor at Derby Wharf being exposed at low tide.

Beyond the Port Limits, the depth of water increases to 30 m in certain points. Deeper areas from 15 m to 30 m are described as basins. Beyond Sunday Strait near the Pilot Boarding Point, the depth increases to 40 m to 50 m and the seafloor feature in this area is terraced.
Figure 40 shows the seafloor features and the bathymetry of King Sound.



Scale: 1:600000
Original Size: A4
Aerial Photo Date: 2016
Aerial Photo Source: Copernicus Sentinel Data
Grid: MGA94(51)
0 10 km

Sheffield Resources
Thunderbird Mineral
Sands Project

Figure 40

Seafloor Features

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MBS ENVIRONMENTAL

W:\Sheffield Resources\PER\Drawings\PER Derby Port.map 21/12/2016 F40 Seafloor Features Layout

4.3.11.2 Tidal Movement

King Sound is a highly dynamic environment and has one of the world's largest tidal ranges of almost 12 m (Table 30). Tides within King Sound are semi-diurnal with a full tidal cycle of approximately 12.5 hours.

Extreme high tide events can leave parts of the Port area inundated, while extreme low tide events can expose the sea bed below the wharf. The tides have been a significant constraint on historical shipping operations from Derby Port, limiting berthing time at the wharf to between six and seven hours.

There are no historical records of a significant storm surge at Derby. The large tidal variations and low probability of a significant cyclone over King Sound results in a low chance of a significant storm tide (BOM 2016a). However, the worst possible scenario of a severe cyclone arriving at high tide and coinciding with floodwaters from the Fitzroy and other rivers into King Sound would likely inundate the Derby townsite. This extreme scenario has a very low probability of occurring (BoM 2016c).

Table 30: Astronomical tides and heights for Derby

Tide	Height (m)
Highest astronomical tide	11.8
Mean spring high tide	9.7
Mean neap high tide	5.4
Mean neap low tide	3.5
Mean spring low tide	0.5
Lowest astronomical tide	0.0

Tidal currents in King Sound reach velocities of 1.5 m/s to 2.0 m/s in open water, and 3 m/s or more in narrow tidal creeks, generally during ebbing spring tides (Semeniuk 1980). Waves in the dry season are up to 1.5 m high when the wind and tide are in opposite directions (Wolanksi and Spagnol 2003).

4.3.11.3 Marine Water Quality Parameters

As part of the Derby Storage Facility Baseline Contamination Assessment (see section 4.3.7), marine water samples were collected near the boat ramp at the site known as DER BR1 (Appendix 14). Water samples were analysed for dissolved metals and general parameters such as pH, electrical conductivity, and total dissolved solids.

Estuarine tidal water sampled at the public boat ramp located to the immediate west of the proposed storage facility indicate no results above the ANZECC and ARMCANZ (2000) EIL trigger values with dissolved metals and metalloids very low, and mostly below laboratory limits of reporting (including for lead, zinc, copper and nickel). As expected for the silt laden waters of this estuary area, the turbidity (62 nephelometric turbidity units) and suspended solids (89 mg/L) were very high. Other general parameters of salt content and salt composition are consistent with typical seawater. Dissolved uranium was observed at a concentration of 0.0035 mg/L, which is consistent with the value reported by Miyake et al. (1966) (as cited in MBS 2016c) of 0.0033 mg/L for seawaters of the western north Pacific (MBS 2016).

A comparison of analytical results for the water sample collected at the boat ramp with ANZECC 2000 EIL trigger values is provided in Table 31.

Table 31: Marine Water Analysis Results

Analyte	Units	DER BR1	ANZECC 2000 Marine Trigger Value
Ag	mg/L	<0.0010	0.0014
Al	mg/L	<0.005	N/G
Alkalinity	mg/L	129	N/G
As	mg/L	<0.010	N/G
Carbonate	mg/L	<1	N/G
Calcium	mg/L	423	N/G
Cadmium	mg/L	<0.0010	0.0007
Chloride	mg/L	19500	N/G
Cobalt	mg/L	<0.0010	0.001
Chromium	mg/L	<0.001	0.027
Copper	mg/L	<0.0010	0.0013
EC	mS/m	5350	N/G
Fe	mg/L	<0.005	N/G
Bicarbonate	mg/L	157	N/G
Potassium	mg/L	447	N/G
Magnesium	mg/L	1240	N/G
Manganese	mg/L	0.017	N/G
Molybdenum	mg/L	0.014	N/G
Sodium	mg/L	11800	N/G
Nickel	mg/L	<0.010	0.007
Lead	mg/L	<0.0010	0.0044
Sulfate	mg/L	2800	N/G
Selenium	mg/L	<0.010	N/G
TSS	mg/L	89	N/G
Thorium	mg/L	<0.0010	N/G
Titanium	mg/L	<0.002	N/G
Turbidity	NTU	62	N/G
Uranium	mg/L	0.0035	N/G
Vanadium	mg/L	0.0036	N/G
Zinc	mg/L	<0.005	0.015
Zirconium	mg/L	<0.002	N/G
pH	pH Units	8	N/G

N/G indicates no guideline value is applicable. NTU are nephelometric turbidity units.

In a study by McAlpine *et al.* (2012) outside of King Sound, it was concluded that the waters are usually clear and that the marine waters of the Kimberley are generally of very high quality. The concentrations of metals across the region were relatively low at the time of sampling and met the guideline trigger values from ANZECC and ARMCANZ (2000) for a very high level of ecological protection. The nearest survey site to the proposed project infrastructure was in the Sunday Strait. The total suspended solids on the surface and bottom at this site were 1 and 2 mg/L respectively. The study also indicated that cobalt may be naturally elevated in some Kimberley coastal waters.

4.3.11.4 Sediment

The sediments in King Sound are mostly of Precambrian and upper Palaeozoic rocks such as sandstones, granite, and porphyritic volcanics. Mean particle size in the Fitzroy Estuary is approximately 1 mm with a maximum grain size of 20 mm (Gellatly 1970 cited in MScience 2011). See Section 4.3.7 for discussion on contamination of marine sediments.

4.3.11.5 Fitzroy River Discharge

The Fitzroy River contributes the most discharge to King Sound. The river has a catchment of around 90,000 km^2 and flows for approximately 733 km from the King Leopold and Mueller Ranges into King Sound. Upstream at Fitzroy Crossing, the river has an average annual flow of 6,150 GL/year making it the largest river in Western Australia in terms of annual flow. During the dry season, the river can cease to flow altogether (Ruprecht and Rodgers cited in Morgan *et al.* 2004).

As a result of its variable flow, discharge from the Fitzroy River is also highly variable thought the year. Discharge is minimal during eight months of the year in the dry season, with nil flow recorded in June to November 1987 (Wolanksi and Spagnol 2003). In the wet season, flows have been recorded up to 30,000 m^3/s (in April 1983), and can be highly unpredictable, with 70-90% of the rainfall and runoff occurring between January and March.

Turbidity within the Fitzroy River can exceed 1,000 nephelometric turbidity units in the wet season.

4.3.11.6 Turbidity Processes

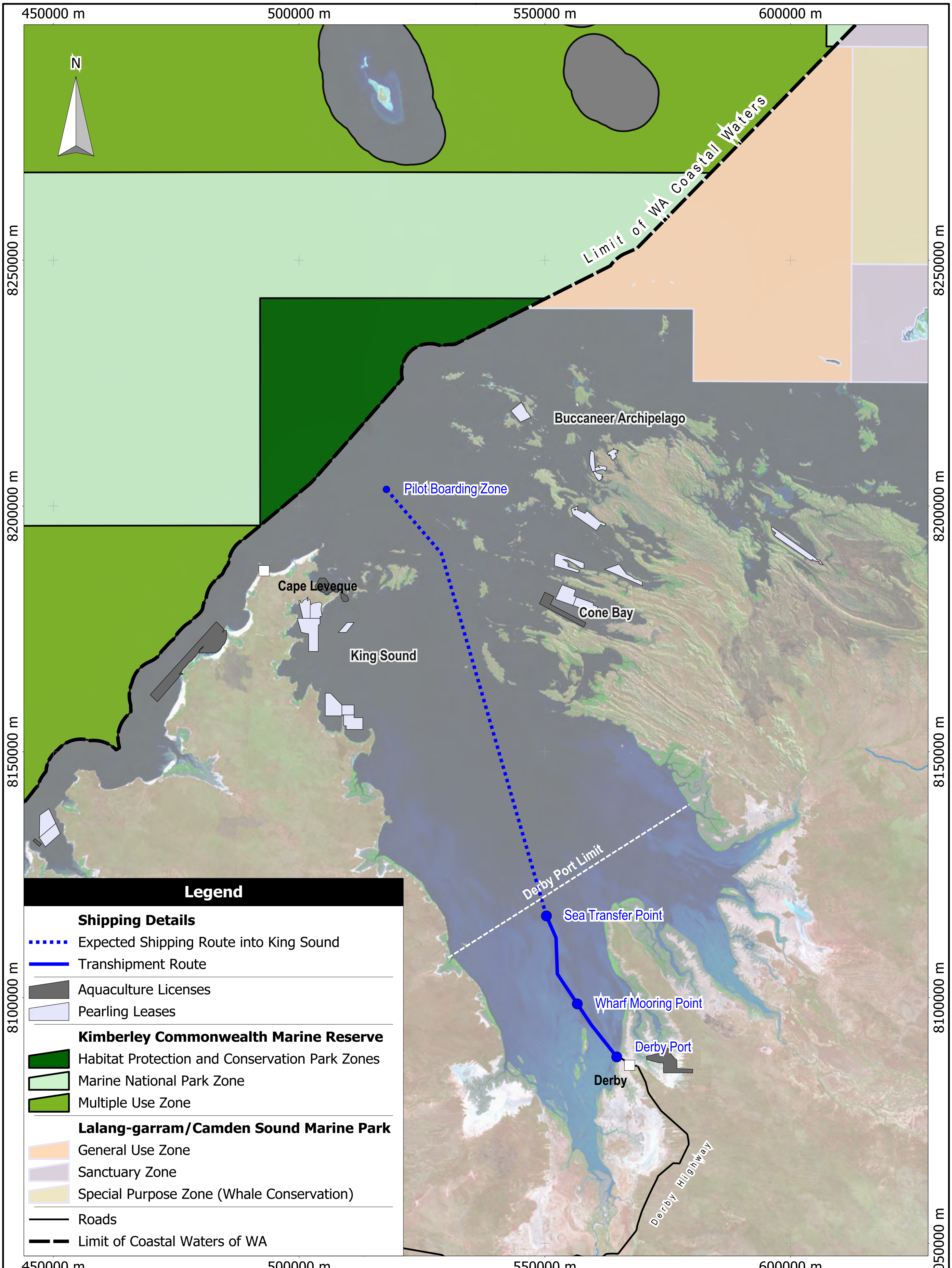
The upper reaches of King Sound are naturally high in turbidity, primarily as a result of Fitzroy River discharge, with suspended solids concentrations reaching 3 kg/m^3. The turbidity maximum is in the upper reaches (southern) and shallow part of the Sound, even in the dry season when inputs from the Fitzroy River are minimal. Based on the limited data available for sediment loading of the river, it is estimated the Fitzroy River transports 10 to 15 million cubic metres of sediment into the upper reaches of King Sound per year (Ruprecht and Rodgers (in prep) cited in MScience 2011).

There are several other processes that contribute to the turbidity maximum occurring in the southern part of the Sound, including wind-driven waves, evaporation-driven elevated salinity and stratification, tidal pumping due to asymmetrical tides (stronger currents on flood tides than ebb tides), and muddy marine snow formed further seaward in the Sound and pushed shoreward by tidal pumping Despite the huge tidal range and flushing, fine sediment does not easily escape King Sound (Wolanksi and Spagnol 2003).

4.3.12 Existing Regional Marine Uses

4.3.12.1 Aquaculture and Pearling

The northwest of King Sound, and the islands and bays of the Buccaneer Archipelago to the northeast of King Sound, support a cultured pearl industry and several aquaculture operations. Cone Bay hosts several pearling sites as well as the Kimberley Aquaculture Development Zone (KADZ). The KADZ is a 2,000 hectare area of water that has been pre-approved by the Department of Fisheries for the development of aquaculture. The zone presently includes a finfish aquaculture facility that is licensed to produce up to 15,000 tonnes per annum of barramundi or other local finfish in floating sea cages, located approximately 90 km north of Derby Port (DoF 2013; Fletcher and Santoro 2015). An indigenous project at One Arm Point features a marine hatchery for ornamental and edible marine species. In addition, Kimberley Prawn Farm holds a licence from the Department of Fisheries for the culture of prawns in ponds near Doctors Creek, although this is not currently operational. Figure 41 shows the location of existing aquaculture and pearling operations.



Scale: 1:1000000 Original Size: A4 Image: Geoscience Australia LS7 2007 Grid: MGA94(51) 0 20 km	Sheffield Resources Limited Thunderbird Mineral Sands Project	**Figure 41** **Existing Regional Marine Uses**	Martinick Bosch Sell Pty Ltd 4 Cook St West Perth WA 6005 Ph: (08) 9226 3166 Fax: (08) 9226 3177 info@mbsenvironmental.com.au www.mbsenvironmental.com.au MBS ENVIRONMENTAL

4.3.12.2 Fishing

Five commercial fishers (four of which were active in the 2014/15 season) hold licenses within the Kimberley Gillnet and Barramundi Fishery, which includes the waters of King Sound and other areas in the north coast bioregion (Fletcher and Santoro 2015). Species caught in this fishery are almost all Barramundi (*Lates calcarifer*), King Threadfin (*Polydactylus macrochir*) and Blue Threadfin (*Eleutheronema tetradactylum*), with 44.2 tonnes of Barramundi and 23.4 tonnes of the two Threadfin species caught in the 2014 fishing year. Small quantities of sharks and rays and other species were reported as bycatch and interaction was reported with one crocodile and 17 Sawfish, with all but one Sawfish reportedly released alive.

The Northern Shark Fishery was closed permanently in 2009 and trawling for fish or prawns is permanently prohibited in King Sound and the surrounding rivers. Other fisheries that may utilise the waters of King Sound or the Buccaneer Archipelago include the Broome Prawn Fishery, the Mackerel Fishery, and the Northern Demersal Scalefish Fishery. There are three emerging fisheries in the area, with several Ministerial Exemptions being issued for the collection of Beche-de-mer, Trochus, and Mud Crab species.

Recreational fishers in King Sound also target Barramundi and Threadfin species. In the north coast bioregion in 2011/12, recreational catches amounted to 8.4 tonnes of Barramundi and 7.0 tonnes of Threadfin species (Fletcher and Santoro 2015).

4.3.12.3 Tourism

The tourism industry utilises the Derby Port and the wider King Sound area. A small number of tour operators run boat tours including mud crab and barramundi fishing tours, and multi-day boat excursions to the Buccaneer Archipelago operate from April to October. Tours range from four to 12 days and villaging or live-aboard options are available. Air charters and seaplane tours run all year depending on demand and weather; scenic flights visit the tidal phenomenon of the “horizontal falls”, and usually the Buccaneer Archipelago (Derby Tourism 2016).

4.3.12.4 Resources

Presently there are no resource projects utilising the Derby Port on a regular basis. The Cockatoo Island and Koolan Island operations previously utilised the Port; however both of these projects have ceased operations and have been placed in care and maintenance, with the Port occasionally utilised for movement of supplies.

4.3.12.5 Shipping

Shipping in the Kimberley is a well-established industry, supporting exports from mining and agricultural industries. The main ports in the Kimberley are Broome and Wyndham, both of which receive ocean-going vessels. Ocean-going vessels do not currently visit the Derby Port, although smaller vessels berth on a regular basis. The number of vessels using Derby Port has dropped to an estimated 120 per year following cessation of mining at Koolan and Cockatoo Islands, with the current vessels being mostly those that support the aquaculture and tourism industries (R. Sullivan, Shire of Derby/West Kimberley, pers. comm.). The total estimated number of ships utilising Kimberley waters per year is approximately 1,500 (Table 32).

Table 32: Numbers of vessels utilising Kimberley Waters 2014/15

Port	Number of Vessels 2014/15 Financial Year^	Reference
Broome	1,126	Kimberley Ports Authority, 2016.
Wyndham	121	G. Taylor, CGL Wyndham Port Ltd, pers. comm.
Derby	268*	R. Sullivan, Shire of Derby/West Kimberley, pers. comm.
Total	**1,515**	

^ Excluding private recreational vessels not using port facilities. ** Only smaller tourist vessels and barges*

4.3.12.6 Marine Reserves

Both State and Commonwealth marine reserves exist in the region, although these are well outside King Sound. The Lalang-garram/Camden Sound Marine Park was created in 2012 under Section 13 of the *Conservation and Land Management Act 1984* about 150 km north of Derby. The subtidal portion of the marine park has been proclaimed and covers an area of approximately 673,000 ha. Within the marine park, various zones have been established including sanctuary zones, special purpose zones (for whale conservation, wilderness and pearling), and general use (DPaW 2013).

Beyond Western Australian coastal waters, the Commonwealth has established the Kimberley Commonwealth Marine Reserve. This reserve covers a total area of 74,469 km^2 and includes a habitat protection zone of 1,129 km^2 (DSEWPC 2012b). Figure 41 shows the two marine protected areas in relation to King Sound.

4.3.13 Benthic Primary Producer Habitat

Benthic primary producer habitats are functional ecological communities that inhabit the seabed within which algae, seagrass, mangroves, corals, or mixtures of these groups are prominent components. Benthic primary producer habitats also include areas of seabed that can support these communities. Benthic primary producer habitats play important roles in maintaining the integrity of marine ecosystems and the supply of ecological services (EPA 2009b).

4.3.13.1 Mangroves

Mangrove communities (mangals) in the Kimberley region display a very high degree of intactness (EPA 2009b). Mangrove forests are the most important benthic primary producers in the wider Derby Port area.

At Derby Port, vegetation surrounding the proposed storage facility is dominated by mangals that lie in a 500 m wide band between the open water of King Sound and extensive saline mudflats.

Approximately 165 km^2 of intertidal mangal habitat occurs within King Sound. In general, around the coastline of King Sound, *Avicennia* dominates the seaward zone, *Rhizophora* the middle zone and *Ceriops* the landward zone. Inland of the intertidal mangals are extensive saline mud flats which are bare and vary from two to four kilometres in width. They are inundated at high spring tide and after heavy rainfall. Where these mud flats extend above the level of the spring high tides, they form grassy or samphire flats (Semeniuk 1980).

Eleven mangrove species are known to occur around King Sound, none of which are conservation significant (Table 33).

Table 33: Mangrove Species at King Sound

Common Name	Scientific Name	Relative Abundance
Club Mangrove	*Aegialitis annulata*	Common
River Mangrove	*Aegiceras corniculatum*	Common
White Mangrove	*Avicennia marina*	Abundant
Ribbed Mangrove	*Bruguiera exaristata*	Uncommon
Smallflower Bruguiera	*Bruguiera parviflora*	Uncommon
Kapok Mangrove	*Villagetostemon schultzii*	Common
Spurred Mangrove	*Ceriops tagal*	Common
Milky Mangrove	*Excoecaria agallocha*	Uncommon
Myrtle Mangrove	*Osbornia octodonta*	Uncommon
Spotted-leaved Red Mangrove	*Rhizophora stylosa*	Common
Cedar Mangrove	*Xylocarpus australasicus*	Uncommon

Source: Semeniuk (1980)

Derby Port

The mangroves of King Sound form associations or communities and are commonly found in predictable groups of species. Johnstone (1990) studied mangrove associations around Derby Port and reported the mangals grow on a long sloping grey mudbank, which assists them to form well-defined belts. On the seaward zone is a thin belt of *Avicennia*. Proceeding landward there is a band of *Villagetostemon*, *Aegialitis*, *Aegiceras* and *Rhizophora* and in many places these are mixed. In some places *Rhizophora* is the only species. The landward zone consists of mainly of *Ceriops* and *Avicennia*, with saline flats found on the landward side of the mangal.

Point Torment

On the northeastern side of Point Torment at Stokes Bay, Johnstone (1990) reported a wide belt of mangroves growing in dark grey mud cut through by many small creeks. The mangals run parallel to the coast and have well defined zonation. The seaward side of the main creeks have the most complex marginal vegetation, with communities of *Rhizophora, Villagetostemon* (along the creeks)*, Bruguiera exaristata, Avicennia and Aegiceras*. On the landward side, the tributaries are more numerous and the marginal vegetation is less diverse, mainly *Avicennia* and *Bruguiera* with some *Ceriops, Villagetostemon* and *Rhizophora*. Closest to the land, the belts consist mostly of scattered *Avicennia*, *Excoecaria* and *Osbornia*, and thickets of *Ceriops*. Landward of the mangal are samphire flats with *Sporobolus virginicus* and landward of this is a belt of *Melaleuca acaciodes*.

4.3.13.2 Other Benthic Primary Producers

Seagrasses require high levels of light penetration in order to conduct photosynthesis. High turbidity is known to impede access to light and therefore the growth of seagrasses in tropical waters (Chartrand *et al*. 2012). In colder waters of Australia, seagrasses are known to occasionally inhabit waters as deep as 45 m. In northern Australia where environments can be extreme, this depth limit is likely to be less. Studies show that large tidal movements, natural turbidity, oceanic swells, or freshwater runoff in the wet season reduce the diversity and extent of seagrasses. Seagrasses in the north of Western Australia only occur sparsely in between coral reef environments or in lagoonal areas where water ponds at low tide (Green and Short 2003). Some areas in the Kimberley are known for high diversity and abundance of seagrasses, with the closest site being One Arm Point (McKenzie and Yoshida 2013). One Arm Point is a shallow site, characterised by much lower turbidity than conditions found in King Sound.

Inshore areas of King Sound are not likely to support seagrasses, as they experience extremely high turbidity levels and large tidal movements. At the pilot boarding point, although the water is less turbid, the water is 40 m - 50 m deep. This depth affects light attenuation, and combined with the extreme tidal fluctuations is likely to prohibit the growth of seagrasses at this point.
Figure 40 shows the seafloor, relative depths of the water in King Sound and the pilot boarding point.

Coral reefs are known to be a diverse and important form of benthic primary producer habitat. Coral reefs usually develop in clear, nutrient poor, shallow waters in tropical oceans. The zooxanthellae algae within the coral polyps require sunlight for photosynthesis to occur. In areas where the water is exceptionally clear, corals have been known to occasionally grow to a depth of 60 m (WA Museum 2016). However, it is noted that the most productive growing depths for coral reefs is 18 m - 27 m (Coral Reef Systems 2016). The high turbidity inside King Sound precludes the growth of corals. The 40 m – 50 m depth at the pilot boarding point prevents the growth of significant amounts of coral at this point (see
Figure 40).

At Cone Bay (to the east of the entrance to King Sound), the Department of Fisheries (2013) found minimal seagrasses and corals grow on mostly bare, sandy, fine to coarse sediments. It is thought that the scarcity of benthic primary producers in this area is due to the lack of hard substrate and the lack of available light due to the relatively high levels of turbidity (DoF 2013). The seafloor at the pilot boarding point may be broadly similar to Cone Bay, and although seagrasses and corals are unlikely to be present, benthic invertebrate and burrowing organism habitat could potentially be present.

4.3.14 Marine Fauna

A search of the following databases was undertaken over the Derby Port Development Envelope and vessel routes to determine marine fauna species that may occur in the area:

- *WC Act* & DPaW Threatened and Priority Fauna Database using a polygon as shown in Appendix 15.
- *EPBC Act* Protected Matters Search Tool as shown in Appendix 16.
- Naturemap database (DPaW 2016a).

In addition to the species found in these database searches, other species of conservation significance were identified through searches of scientific literature.

For the marine and migratory species, a total of 40 birds, 32 fish (including sharks and rays), 16 mammals and 22 reptile species were identified during the database searches. Most of the species are common and well represented in the region.

4.3.14.1 Species of Particular Concern

Species of particular concern to the project include the following, all of which were raised by DoEE during preparation of the Environmental Scoping Document, but were not listed as part of the *EPBC Act* 'Controlled Action' decision:

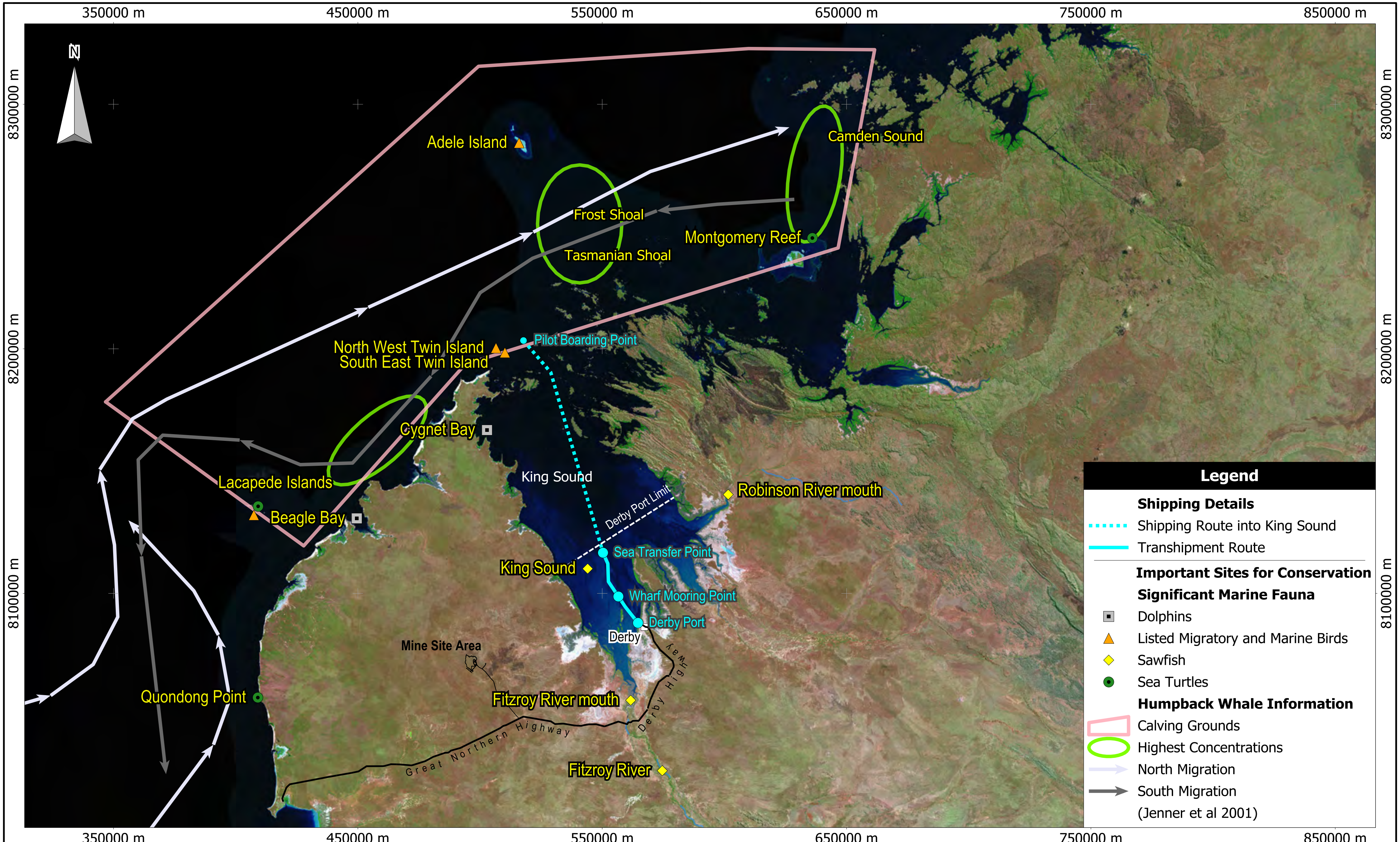
- Humpback Whale (*Megaptera novaeangliae*) – listed as Vulnerable under the *EPBC Act*.
- Dwarf Sawfish (*Pristis clavata*) – listed as Vulnerable under the *EPBC Act.*
- *Green Sawfish (Pristis zijsron) – listed as Vulnerable under the EPBC Act*.
- Largetooth Sawfish (*Pristis pristis*) – listed as Vulnerable under the *EPBC Act*.
- Northern River Shark (*Glyphis garricki*) – listed as Endangered under the *EPBC Act*.

Humpback Whale

The Humpback Whale is known to occur in significant numbers in the Kimberley region. Whales migrating up the west coast of Australia belong to a distinct population (Group IV population) to those occurring on the east coast of Australia (Group V population). The total number of whales in the Group IV population is estimated to be 21,750 (Hedley *et al*. 2008), although only a small proportion of these pass the mouth of King Sound each year between the months of July and November on their south/north migration to calving grounds. Humpback Whales do not use King Sound as a calving ground and the area is not part of the whale migration path.

Humpback whale calving grounds occur from Broome to north of Camden Sound, with the greatest concentration of calving whales found near Camden Sound (Jenner *et al*. 2001). Camden Sound is considered the most important Humpback calving site in the southern hemisphere, and the State and Commonwealth waters in the area are protected by marine reserves. Both include habitat protection areas in recognition of the importance of the area to whales (DPaW 2013; DoEE 2016c).

The Group IV population mostly favours a fixed migration route known as the 'whale highway', which tends to follow the series of shelf-edge canyons that occurs off the west coast. Most whales appear to prefer the 20 m depth contour (Hedley *et al*. 2008; SoE 2011). Most whales on their north and south-bound migration pass to the west of the Lacepede Islands to avoid the shoals inshore and a substantial number also pass further offshore (Double *et al*. 2010). When heading north from the Lacepede Islands, most whales remain offshore, pass the mouth of King Sound, and aggregate at the Frost and Tasmanian Shoals. These shoals are most likely used as staging grounds where whales wait for the right tidal conditions to proceed to or from Camden Sound. Figure 42 shows the areas of highest concentration of whales and main migration routes used by Humpback Whales in the region (Jenner *et al.* 2001).



Scale: 1:2000000
Original Size: A4
Image: Geoscience Australia LS7 Mosaic 2007
Grid: MGA94(51)

0 50 km

Sheffield Resources
Thunderbird Mineral Sands Project

Figure 42

Important Habitat for Conservation Significant Marine Fauna

4 Cook St
West Perth WA 6005
Ph: (08) 9226 3166
Fax: (08) 9226 3177
info@mbsenvironmental.com.au
www.mbsenvironmental.com.au
MBS ENVIRONMENTAL

W:\Sheffield Resources\PER\Drawings\PER Derby Port.map 21/12/2016 F42 Important Habitat for Conservation Significant Marine Fauna Map Layout

Sawfish and Sharks

Sawfish are shark-like rays, and three species are known to occur in the King Sound area: Dwarf Sawfish (*Pristis clavata),* Green Sawfish (*P. zijsron)* and Largetooth Sawfish *(P. pristis).* All of these Sawfish are considered Vulnerable under the *EPBC Act*, with breeding likely to occur in the area (DoE 2015a). The Dwarf Sawfish is also listed as Priority 1, and the Largetooth Sawfish as Priority 3 by DPaW. The Green Sawfish is listed as Vulnerable under the *WC Act*. All three species of Sawfish and the Northern River Shark are also protected under the *Fish Resources Management Act 1994*.

The main threats to the Sawfish are associated with bycatch from commercial fishing using nets and entanglement in marine debris. The barbed rostrum and inshore and estuarine habitat preferences of the Sawfish mean they are sometimes caught as bycatch by fishers targeting Barramundi or King Salmon, however the impact of recreational fishers on the species is currently unquantified (DoE 2015b). Habitat modification caused by developments in the Sawfish species' range may also represent a threat, but to date these have been of lesser concern than fishing (DoE 2015b). Threats to Sawfish also include the shark-fin trade, which is known to occur within Australian waters, and collection of the rostrums as curios.

Dwarf Sawfish

The Dwarf Sawfish is found in tropical waters of Australia from south of Port Hedland to eastern Cape York Peninsula (DoE 2015b). It prefers habitats of 2-3 m depth in coastal and estuarine waters and does not use any purely freshwater habitats. Thorburn *et al.* (2007a) studied Dwarf Sawfish in King Sound and several of the Sound's river estuaries. They determined that estuarine, and possibly brackish habitats in the Fitzroy River, are used as nursery areas and juveniles may stay in these areas until three years of age. Stevens *et al.* (2008) found the Dwarf Sawfish had limited daily movements and a range of only a few square kilometres. Its movements are influenced by the tides, with high tide being spent resting in inundated mangroves and on a moving tide they are active, presumably feeding. No habitat suitable for the species is located within the Mine Site Development Envelope.

Green Sawfish

The Green Sawfish was historically found throughout the Indian Ocean to South Africa and Indonesia, however the species' range is now considered to be much reduced. In Australia, the species currently occurs from Shark Bay in Western Australia to the Whitsundays in Queensland and it utilises marine and estuarine waters, but not freshwater (Harry *et al.* 2011; Stevens *et al.* 2005). In a recent paper by Morgan *et al.* (2015), a large influx of Green Sawfish pups was reported for the Ashburton Estuary in the Pilbara. The authors speculate this may be the most important nursery area for the species globally. As with the Dwarf Sawfish, Stevens *et al.* (2008) found the movements of the Green Sawfish to be tidally influenced. The Green Sawfish swim towards mangroves on the incoming tide and away from mangroves on the outgoing tide. The species is thought to be long lived, reaching maturity at around nine years of age, and reaching 95% of its maximum size at 24 years of age (Stevens *et al.* 2005). It is a species of low fecundity, which contributes to its Vulnerable status under the *WC Act*. No habitat suitable for the species is located within the Mine Site Development Envelope.

Largetooth Sawfish

The Largetooth Sawfish, previously known as the Freshwater Sawfish (*Pristis microdon)*, is the largest of the three species of Sawfish found in the Kimberley (DoE 2015a). Its range in Australian waters is from Port Hedland in WA to Cooktown on the Cape York Peninsula in Queensland (DoE 2015b). The freshwaters of the Fitzroy River are a nursery for this species, with immature fish remaining in the river until up to five years of age. This is the only species of Sawfish to utilise purely freshwater habitats and it has been found up to 400 km inland (DoE 2015b). Mapping of potential habitat of the species shows juveniles may occur in the wet season in Fraser River and Fraser River South, the headwaters of which are around 4 km from the Mine Site. As the fish matures, it is found in estuarine and marine habitats including King Sound (Thorburn *et al.* 2007b). It has a worldwide distribution, although Australia may be the last viable population stronghold (DoE 2015a).

Northern River Shark

The Northern River Shark (*Glyphis garricki*) is known from King Sound in the west to the Northern Territory, west of the Gulf of Carpentaria and may potentially use King Sound as a pupping ground (DoE 2015b). The Northern River Shark is found only in Australia and Papua New Guinea. Juveniles may occupy freshwater habitats and adults are found in estuarine and marine habitats (Pillans *et al.* 2009). Males of the species are thought to mature at 14 years of age, and females at 17 years. Life expectancy is predicted to be more than 25 years (Stevens *et al.* 2005). Threats to the shark include commercial gill-net fishing, with the shark being recorded in the bycatch in the Kimberley Gillnet and Barramundi Fishery and recreational fishing (Fletcher and Santoro 2015). Habitat modification, such as restriction of tidal flow or damming of preferred rivers is also of concern for the species.

4.3.14.2 Threatened, Migratory and Marine Species

Several marine species are listed as Threatened or Migratory under the *EPBC Act*, Vulnerable or Endangered under the *WC Act* or listed as a Priority species by DPaW. These species have been termed ‘conservation significant’ species.

A summary of Marine and Migratory fauna of conservation significance with potential to occur within and around the Derby Port Development Envelope or the transhipment route is provided in Table 34. Of the 20 conservation significant species identified in the searches, there are four birds, seven reptiles, six sharks and three mammals. Important habitat for these species is illustrated in Figure 42.

Table 34: Threatened Marine and Migratory Fauna – King Sound

Species	Conservation Status			Habitat	Likelihood of Occurrence	Recorded
Name	EPBC Act	WC Act	DPaW			
Birds						
Australian Painted Snipe *Rostratula australis**	E	T(E*)	-	Cryptic and scarce species generally inhabiting ephemeral, seasonal or temporary wetlands. Records for western part of Dampier Peninsula, but most records are in eastern Australia (Birdlife 2016).	Medium – possible	No
Curlew Sandpiper *Calidris ferruginea*	CE, M	T(V)	-	Occurs around the coast on intertidal mudflats in sheltered coastal areas, such as estuaries, bays (DoE 2016).	High Recorded previously, non-breeding.	Yes (Birdlife 2016)
Eastern Curlew *Numenius madagascariensis*	CE, M	T(V)		Primarily has coastal distribution in non-breeding range. Roosts on sandy spits and islets, especially on dry beach sand near the high-water mark (DoE 2016).	High Recorded previously, non-breeding.	Yes (Birdlife 2016)
Lesser Sand Plover *Charadrius mongolus*	-	T(E)	-	Feeds mostly on extensive, freshly-exposed areas of intertidal sandflats and mudflats in estuaries or beaches. Roost near foraging areas, on beaches, banks and spits (DoE 2016).	High Recorded previously, non-breeding.	Yes (Birdlife 2016)
Reptiles						
Flatback Turtle *Natator depressus*	V, M	T(V)	-	Recorded from King Sound and known to feed in shallow, turbid waters. Unpublished account of nesting at Point Torment (R.I. Prince, pers. comm. cited in SWOT 2009). Not expected to be a major nesting site.	High Often found in turbid waters	Yes (NatureMap, DPaW Threatened Fauna Search 2016). Recorded outside of Port Limits on eastern side of King Sound.
Green Turtle *Chelonia mydas*	V, M	T(V)	-	Pelagic for first 5-10 years and then prefers shallow benthic foraging habitats such as coral and rocky reef habitat or inshore seagrass beds. Neither of these habitats occurs in King Sound. Uncommon in King Sound, but common at offshore islands of the Kimberley (DoE 2016).	Medium Outside King Sound.	Yes (NatureMap, DPaW Threatened Fauna Search 2016). Sighted near Port.

Species	Conservation Status			Habitat	Likelihood of Occurrence	Recorded
Name	EPBC Act	WC Act	DPaW			
Hawksbill Turtle *Eretmochelys imbricata*	V, M	T(V)	-	Nesting occurs in the Dampier Archipelago and foraging may occur throughout the region in coral and/or rocky reef habitat (Limpus 2009a).	Low Suitable habitat not found.	No
Leatherback Turtle *Dermochelys coriacea*	E, M	T(V)	-	A pelagic species rarely nesting in Australia. Very wide-ranging in its distribution, but preferring open ocean habitats (Limpus 2009b), although one record exists near One Arm Point.	Low – prefers open ocean	No
Loggerhead Turtle *Caretta caretta*	E, M	T(E)	-	No breeding in area and no critical feeding habitats. Foraging may occur in a wide range of habitats including rocky and coral reef, seagrasses and estuaries (DSEWPC 2012b).	Medium Rarely found inside King Sound	Yes (DPaW Threatened Fauna Search 2016). Recorded near Point Torment.
Olive Ridley Turtle *Lepidochelys olivacea*	E, M	T (E)		The least common turtle in the area. Rarely nests in WA near Camden Sound (DPaW 2016e), mostly nests in Northern Territory. Forages on invertebrates from soft bottoms (DSEWPC 2012b).	Low Uncommon in Australia.	Yes (NatureMap, DPaW Threatened Fauna Search 2016). Two records near One Arm Point, no sightings inside King Sound.
Short-nosed Seasnake *Aipysurus apraefrontalis*	CE	T(CE)	-	Significant habitats are not near the King Sound area (DSEWPC 2012b).	Low Prefers coral reefs	No
Sharks						
Dwarf Sawfish *Pristis clavata*	V, M	-	P1	Known to inhabit the area of the Fitzroy estuary and King Sound (Thorburn *et al.* 2007a).	Medium In King Sound but uncommon	Yes (Thorburn *et al.* 2007a)
Great White Shark *Carcharodon carcharias*	V, M	T(V)	-	Oceanic, temperate waters (DSEWPC 2013)	Low Habitat not suitable.	No
Green Sawfish *Pristis zijsron*	V, M	T(V)	-	May inhabit King Sound and estuarine or brackish locations nearby (DoE 2015a).	Medium In King Sound but uncommon	Yes (DoE 2015b)

Species	Conservation Status			Habitat	Likelihood of Occurrence	Recorded
Name	**EPBC Act**	**WC Act**	**DPaW**			
Largetooth Sawfish *Pristis pristis*	V, M	-	P3	Uses the freshwaters of the Fitzroy River and some tributaries as a nursery and moves into estuarine and marine habitats when it matures (Thorburn *et al*. 2007b).	Medium In King Sound but uncommon	Yes (Thorburn *et al*. 2007b)
Northern River Shark *Glyphis garricki*	E	-	P1	Known to occur in King Sound and estuarine and freshwater habitats (DoE 2015a).	Medium In King Sound but uncommon	Yes (DoE 2015b)
Whale Shark *Rhincodon typus*	V, M	Schedule 7	-	Oceanic, associated with coral reefs (DEH 2005).	Low Habitat not suitable.	No
Mammals						
Humpback Whale *Megaptera novaeangliae*	V, M	Schedule 6	-	Prefers oceanic waters around the 200 m isobath (Jenner *et al*. 2001).	High Waters outside King Sound	Yes (Jenner *et al*. 2001)
Australian Humpback Dolphin *Sousa sahulensis*	M	-	P4	Shallow estuarine, river mouth and coastal waters of less than 10 metres depth, including turbid waters (Hanf *et al*. 2015).	High Known from King Sound	Yes (Brown *et al*., 2016)
Snubfin Dolphin *Orcaella heinsohni*	M	-	P4	Shallow estuarine, river mouth and coastal waters (Allen *et al*. 2012).	High Known from King Sound	Yes (Brown *et al*., 2016)

Legend:
T – Threatened; V – Vulnerable; E – Endangered; CE – Critically endangered; M – Migratory; P – Priority list; '-' No classification.

** Rostratula australis is listed as Endangered under the WC Act as Rostratula benghalensis australis.*

Marine and Migratory Birds

Marine birds are birds that spend most of their lives at sea, coming to land to breed, with several species known to breed in the region (DSEWPC 2012c). Migratory shorebirds can also be found in the region, as many nest in the northern hemisphere summer in Siberia and Alaska and migrate to Australia in the Australian winter and spring, to return north in March and April. The migration occurs within the East Asian – Australasian Flyway, which is one of ten migratory bird flyways recognised worldwide (Bamford *et al*. 2008; DSEWPC 2012c).

In addition to the conservation significant birds listed in Table 34, there are 36 species of migratory birds protected under international agreements[1] that may overfly the Derby Port area, some of which may breed near the port and transhipment route (Table 35). None of the birds identified are listed as threatened under the *EPBC Act* or *WC Act*.

Table 35: Migratory Birds Protected Under International Agreement

Scientific Name	Common Name	Recorded Near Derby Port (DPaW Fauna Search) or Birdata Atlas Species Distribution Maps	Potentially Occurring Near Derby Port (EPBC Act Protected Matters Search Tool)
Actitis hypoleucos	Common Sandpiper	Yes	Yes
Anous stolidus subsp. ileatus	Common Noddy	-	Yes
Apus pacificus subsp. pacificus	Fork-tailed Swift	Yes	Yes
Ardea alba	Great Egret	-	Yes
Ardea ibis	Cattle Egret	Yes	Yes
Ardea modesta	White-necked Heron	Yes	Yes
Ardea sacra subsp. sacra	Eastern Reef Egret	Yes	Yes
Arenaria interpres interpres	Ruddy Turnstone	Yes	-
Calidris acuminata	Sharp-tailed Sandpiper	Yes	-
Calidris alba	Sanderling	Yes	Yes
Calidris ruficollis	Red-necked Stint	Yes	Yes
Calonectris leucomelas	Streaked Shearwater	-	Yes
Cecropis daurica	Red-rumped Swallow	-	Yes
Charadrius leschenaultii	Greater Sand Plover	Yes	Yes
Charadrius veredus	Oriental Plover	-	Yes
Cuculatus opatus	Oriental Cuckoo	Yes	Yes
Fregata ariel	Lesser Frigatebird	-	Yes
Glareola maldivarum	Oriental Pratincole	Yes	Yes
Haliaeetus leucogaster	White-bellied Sea-Eagle	Yes	Yes
Hirundo rustica	Barn Swallow	Yes	Yes
Limosa lapponica	Bar-tailed Godwit	Yes	Yes
Limosa limosa	Black-tailed Godwit	Yes	Yes
Numenius minutus	Little Curlew	Yes	Yes
Numenius phaeopus	Whimbrel	Yes	Yes
Merops ornatus	Rainbow Bee-eater	Yes	Yes

[1] International agreements include Japan-Australian Migratory Bird Agreement, China-Australia Migratory Bird Agreement, and Republic of Korea-Australia Migratory Bird Agreement.

Scientific Name	Common Name	Recorded Near Derby Port (DPaW Fauna Search) or Birdata Atlas Species Distribution Maps	Potentially Occurring Near Derby Port (EPBC Act Protected Matters Search Tool)
Motacilla cinerea	Grey Wagtail	-	Yes
Motacilla flava	Yellow Wagtail	Yes	Yes
Pandion haliaetus	Osprey	Yes	Yes
Plegadis falcinellus	Glossy Ibis	Yes	Yes
Pluvialis fulva	Pacific Golden Plover	Yes	Yes
Pluvialis squatarola	Grey Plover	Yes	Yes
Sternula albifrons	Little Tern	-	Yes
Sterna dougallii subsp. gracilis	Roseate Tern	-	Yes
Tringa glareola	Wood Sandpiper	Yes	Yes
Tringa nebularia	Common Greenshank	Yes	Yes
Tringa stagnatilis	Little Greenshank	Yes	-

Most habitats of particular importance to conservation significant bird species are found on offshore islands and further west near 80 Mile Beach and Roebuck Bay. The closest areas of significance to the Derby Port Development Envelope are the Lacepede Islands, Adele Island and North-east and North-west Twin Islands. In addition, the Derby Sewage Ponds are listed as an area of international importance for the Little Curlew. Table 36 shows the species for which these areas are particularly significant. Figure 42 shows the proximity of the Derby Port Development Envelope to these significant bird habitats.

Table 36: Significant Habitats for Marine and Migratory Birds

Site	Common Name	Scientific Name	Conservation Significance	Maximum No. Birds Recorded	Reference
Lacepede Islands	Grey-tailed Tattler	*Tringa brevipes*	Marine, Migratory	500	1
	Ruddy Turnstone	*Arenaria interpres*	Marine, Migratory	1,050	1
	Brown Booby	*Sula leucogaster*	Marine, Migratory	18,000	2
	Roseate Tern	*Sterna dougallii*	Marine, Migratory	20,000	2
Adele Island	Lesser Frigate Bird	*Fregeta ariel*	Marine, Migratory	10,140	3
	Grey-tailed Tattler	*Tringa brevipes*	Marine, Migratory	5,500	3
	Brown Booby	*Sula leucogaster*	Marine, Migratory	17,000	3
Northeast and Northwest Twin Islands	Roseate Tern	*Sterna dougallii*	Marine, Migratory	Major breeding colony	4
Derby Sewage Ponds	Little Curlew	*Numenius minutus*	Marine, Migratory	5,000	1

Reference Key: 1: Bamford et al. (2008); 2: Birdlife (2016); 3: Birdlife (2016); 4: Mustoe and Edmunds (2008)

Inshore Dolphins

In the vicinity of King Sound, there are three species of dolphin of conservation significance that may occur: Australian Humpback Dolphin (*Sousa sahulensis*; listed as Migratory and a Cetacean under the *EPBC Act* and as Priority 4 by DPaW), Snubfin Dolphin (*Orcaella heinsohni;* listed as Migratory and a Cetacean under the *EPBC Act* and as Priority 4 by DPaW) and Indo-Pacific Bottlenose Dolphin (*Tursiops aduncus*; listed as Migratory and a Cetacean under the *EPBC Act*).

The Australian Humpback Dolphin is known to occur in coastal waters of Western Australia as far south as Shark Bay, and is endemic to Australia and New Guinea. The species is poorly studied; however the available data indicate that the local populations may be quite distinct from one another and that these populations are discontinuously distributed, exhibiting site fidelity (Parra *et al*. 2004; Parra *et al*., 2006). The species is thought to prefer shallow estuarine, river mouth and coastal waters of less than 10 m depth. Brown *et al.* (2012) studied Australian Humpback Dolphins at North-west Cape and recorded animals in waters from 1.2 to 20 m deep and at ranges from 0.3 to 4.5 km off the coastline. Around one quarter of the individuals recorded were found in mixed groups with Indo-Pacific Bottlenose Dolphins. Australian Humpback Dolphins may be associated with intertidal areas including those around islands and can utilise a range of inshore habitats including turbid waters (Hanf *et al.* 2015; Allen *et al*. 2012). Accurate population numbers are not available, but one estimate for total numbers in Western Australia is less than 5,000 (Bejder *et al*. 2012).

The Snubfin Dolphin is endemic to Australian waters. Like the Australian Humpback Dolphin, information on the Snubfin Dolphin is scarce. The two species have some habitat overlap and the Snubfin Dolphin is known to live in shallow, coastal and estuarine waters. The species is known from King Sound with several records on the NatureMap search facility (DPaW 2016a). The species has been recorded as far south as Exmouth Gulf, although it is more commonly recorded in Roebuck Bay, which is thought to be an important site for the species (Allen *et al*. 2012; Brown *et al.* 2016).

The Indo-Pacific Bottlenose Dolphin often associates with the Australian Humpback Dolphin and Snubfin Dolphin. Little is known of the species' abundance across northern Australia. The species was recently separated from Common Bottlenose Dolphins (*Tursiops truncatus*) and its range is considered fragmented (Allen *et al.* 2012; Brown *et al.* 2016).

Table 37 shows the relative abundance of the three species of dolphin of conservation significance that may occur in King Sound (Brown *et al*. 2016).

Table 37: Approximate Numbers of Dolphins at Kimberley Sites

Location	Snubfin Dolphin	Australian Humpback Dolphin	Indo-Pacific Bottlenose Dolphin
Cygnet Bay	54^	20^	60^
Cone Bay	20*	12*	0
Beagle Bay	2*	7*	184^
Roebuck Bay	133^	12*	9*

*Source: Brown et al. (2016). Key: ^ Highest count for estimated total population size at each site; * indicates insufficient data was gathered to determine population size. The number listed is the maximum number of individuals sighted on any of the repeated surveys.*

The abundance of the dolphin species varies markedly per site. Brown *et al*. (2016) noted that a fifth site, Inner Cambridge Gulf, which had highly turbid and estuarine conditions, showed the lowest abundance of any dolphin species. It was speculated that dolphins may avoid certain sites due to habitat and prey distribution, predation risk or social dynamics. Repeated sampling over various seasons at Cygnet Bay found that Snubfin Dolphins were resident in the area with almost no emigration to other populations. Australian Humpback and Indo Pacific Bottlenose Dolphins also showed site fidelity, but with movement of some individuals between Cygnet Bay and other areas. The study also found that some sites are far more important for one species than others.

Sharks

Whale Shark

The Whale Shark is migratory and known from many tropical and sub-tropical waters. In Australia, the shark has specific aggregation points and these are Ningaloo Reef, and to a lesser extent Christmas Island and the Coral Sea (off Queensland) (DEH 2005). Whale sharks are most commonly found around Ningaloo Reef and northwards along the 200 m isobath (DSEWPC 2012b). Once the migrating sharks reach the Dampier Terrace and Argo Abyssal Plain, most move into oceanic waters (Wilson et al. 2006, cited in DoE 2016).

Aggregations of Whale Sharks appear to be associated with pulses in food, such as following a mass coral spawning. While it is possible for Whale Sharks to occur in King Sound, the species is considered an oceanic species preferring clear water (DEH 2005). There were no records from NatureMap or the DPaW fauna search of the species in King Sound.

Great White Shark *(Carcharadon carcharias)*
While it is noted that the Great White Shark does occasionally occur in tropical waters, this is considered rare. The regular range of the species in Australia is from central Queensland, around the southern coast and only occasionally as far north as North West Cape. Particular foraging areas are known around islands and coastlines that are home to seals and sealions (Last and Stevens 2009 cited in DSEWPC 2013; DSEWPC 2012b). There were no records from NatureMap or the DPaW fauna search of this species in King Sound.

Sea Turtles
Six of the seven species of sea turtle worldwide have the potential to occur in the region of the project: the Flatback Turtle (*Natator depressus*), Green Turtle (*Chelonia mydas*), Hawksbill Turtle (*Eretmochelys imbricata*), Leatherback Turtle (*Dermochelys coriacea*), Loggerhead Turtle (*Caretta caretta*), and the Olive Ridley Turtle (*Lepidochelys olivacea*) (DSEWPC 2012b). The Flatback, Green, and Hawksbill Turtles are listed under the *EPBC Act* as Vulnerable and Migratory. The Leatherback, Loggerhead, and Olive Ridley are listed as Endangered and Migratory under the *EPBC Act*.

DSEWPC (2012b) stated that in the North-west Marine Region, there are several areas of critical habitat for sea turtles based on their importance as foraging grounds or nesting and inter-nesting sites. None of these areas are in close proximity to King Sound, and the Sound is not considered critical habitat for sea turtles. Critical habitats for sea turtles are shown on Figure 42. Neither the Hawksbill Turtle, nor the Leatherback Turtle have been recorded in or around King Sound. Through the EPBC and DPaW search tools, the other four species have been recorded in or around King Sound. Records of each species and the likelihood of occurrence are shown in Table 34.

Sea Snakes
The Short-nosed Seasnake is endemic to the North-west Marine Region and offshore oceanic reef areas. Scarce data are available on the species' habitat preferences, although most specimens have been collected from Ashmore and Hibernia Reefs, where seasnakes species were previously diverse and abundant. The number of seasnakes found on Ashmore Reef has declined rapidly, with the Short-nosed Seasnake now considered to be locally extinct at this location (Lukoscheck *et al.* 2013). The Short-nosed Seasnake utilises coral reef habitat and usually stays within 50 m of the coral reef. As a result, this species is unlikely to be found in King Sound and has not been recorded using EPBC and DPaW search tools in King Sound.

Marine and Migratory Fauna
In addition to the threatened marine fauna listed in Table 34, there are seven species of migratory fauna protected under an international agreement known as the Bonn Convention. These species may occasionally pass by King Sound or the transhipment route (Table 38). None of these species are listed as threatened under the *EPBC Act* or *WC Act*. Given the habitat preferences and the wide ranging nature of these migratory marine fauna species, they are unlikely to be encountered on a regular basis, with the exception of the Indo-Pacific Bottlenose Dolphin.

Table 38: Migratory Marine Fauna Protected Under Bonn Convention

Scientific Name	Common Name	Likely Occurrence
Balaenoptera edeni	Bryde's Whale	Potential to occasionally occur in the ocean-going vessel route. Found Australia-wide (DoE 2016).
Crocodylus porosus	Salt-water Crocodile	Likely to occasionally occur near Derby Port. Found in the ocean and most major river systems of the Kimberley (DoE 2016).
Dugong dugon	Dugong	Unlikely to occur as suitable habitat (seagrass beds) are not present (DoE 2016).
Manta alfredi	Reef Manta Ray	Unlikely to occur. Prefers coral or rocky reef habitats (IUCN 2016).
Manta birostris	Giant Manta Ray	Unlikely to occur. Prefers coral reef and offshore oceanic habitats (IUCN 2016).
Orcinus orca	Killer Whale	Potential to occasionally occur in the ocean-going vessel route. Mostly prefers oceanic habitats, often close to seal colonies (DoE 2016).
Tursiops aduncus	Indo-Pacific Bottlenose Dolphin	Confirmed as occurring in coastal areas near the mouth of King Sound (Brown *et al.* 2016).

4.3.15 Heritage

4.3.15.1 Aboriginal Heritage

A search of the Derby Port Development Envelope and surrounds was undertaken using the Department of Aboriginal Affairs 'Aboriginal Heritage Inquiry System'. Searches were undertaken for the Derby Port Development Envelope to identify the following:

- Aboriginal heritage surveys over or near the Derby Port.
- Registered heritage places within or near the Derby Port Development Envelope.
- Other Heritage Places within or near the Derby Port Development Envelope.

No Registered Sites or Other Heritage Places are present within the Derby Port Development Envelope or transhipment route (DAA 2016). The transport route along the Great Northern Highway to Derby Port has been previously surveyed as part of the Great Northern Highway survey area. No surveys have been undertaken within the Derby Port Development Envelope as it is an established industrial zone.

4.3.15.2 European Heritage

The Derby Port was established in 1880 to ship general supplies from Perth to the pastoral leases of the West Kimberley. The Port was later used to transport wool, cattle, lead and zinc ores. Some of the historic cattle yards remain adjacent to the proposed storage facility. Derby is also the Western end of the Gibb River Road which was constructed for pastoralists to transport their cattle from north eastern pastoral stations for export.

Strickland-Munro *et al.* (2016) conducted a community survey to determine ways in which people value the Kimberley coastline. The results for Derby indicated that people in the community value the area for its European heritage foremost, and secondarily for its recreational fishing, learning, and research opportunities and for economic reasons.

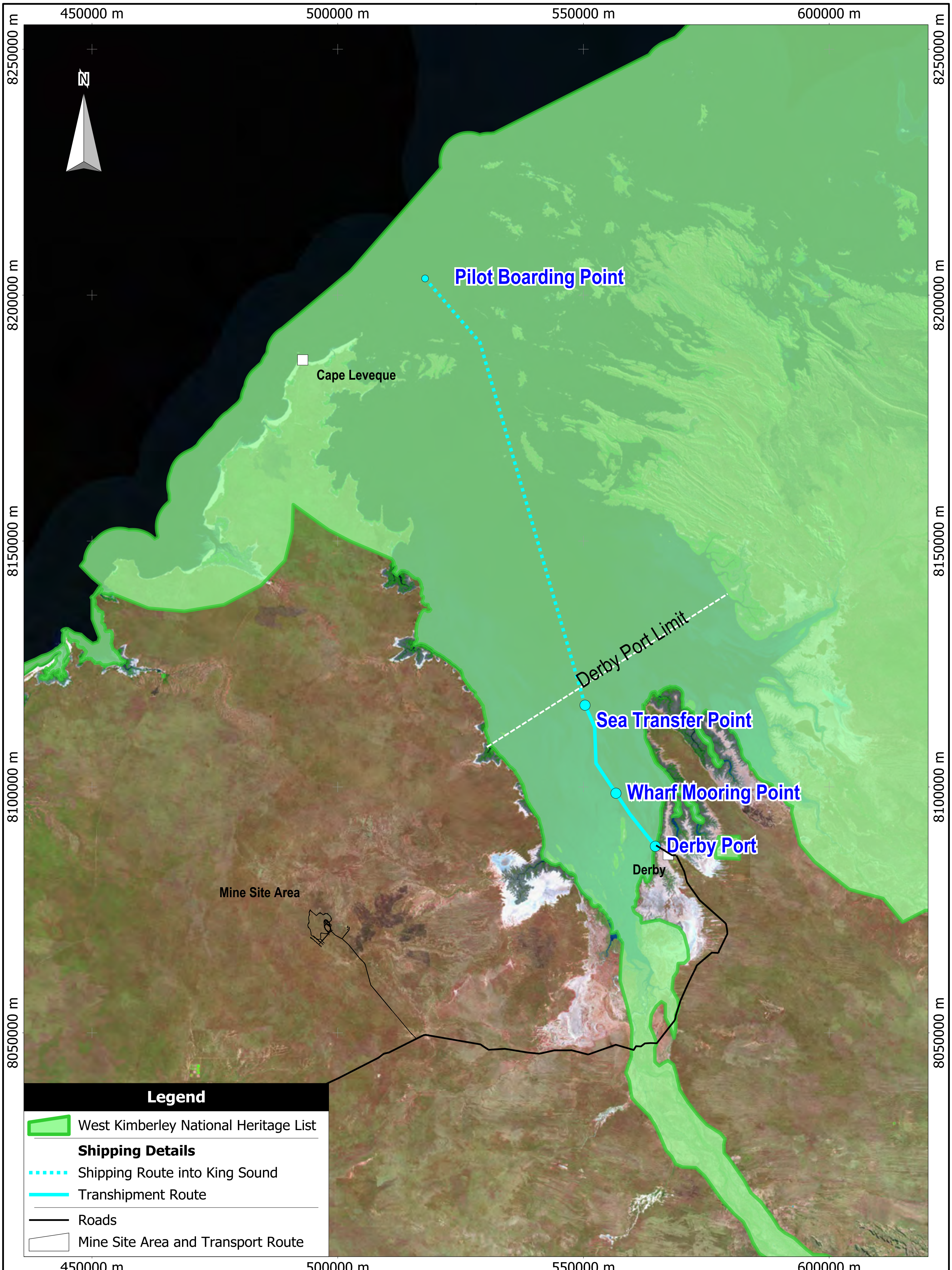
A search of the following databases was carried out to identify registered, non-Aboriginal heritage sites:

- *EPBC Act* Protected Matters (Search Tool).
- Commonwealth Heritage List (CHL).
- World Heritage List (WHL).
- Western Australia Register of Heritage Places.
- Shire of Derby/West Kimberley Municipal Register of Heritage Places.

No municipal, State, CHL, or WHL places were identified within the Derby Port Development Envelope.

The West Kimberley National Heritage Place (WKNHP) (Figure 43), protected under the *EPBC Act*, was found to occur within the Derby Port Development Envelope. It was gazetted on 31 August 2011 based on a number of key heritage values and comprises most of the west Kimberley covering an area of around 19 million hectares. Key heritage values relate to dramatic landscapes, ancient geology, biological richness, Aboriginal culture, early European exploration and pastoral and pearling history.

King Sound is included in the WKNHP due to its association with early European exploration by William Dampier and the influence of his published observations. William Dampier was known to land in several places to the north-west of King Sound (i.e. Karrakatta and Pender Bays). The environment in these places is mostly unmodified since his 1688 landing (Commonwealth of Australia 2011).



Scale: 1:1000000 Original Size: A4 Image: Geoscience Australia LS7 Mosaic 2007 Grid: MGA94(51) 0 20 km	Sheffield Resources Limited Thunderbird Mineral Sands Project	**Figure 43** **West Kimberley National Heritage Place**	Martinick Bosch Sell Pty Ltd 4 Cook St West Perth WA 6005 Ph: (08) 9226 3166 Fax: (08) 9226 3177 info@mbsenvironmental.com.au www.mbsenvironmental.com.au MBS ENVIRONMENTAL

W:\Sheffield Resources\PER\Drawings\PER Derby Port.map 21/12/2016 F43 West Kimberley Heritage Place Layout

4.3.16 Air Quality

No background measurements of air quality could be found within the literature for Derby. However, as there are no significant emissions sources within the Derby region, air quality is expected to be good, but may be affected by dust generation from unsealed roads, deposited dust on sealed roads that is remobilised by traffic and occasionally by smoke from bushfires (Atmospheric Solutions 2016b).

The Derby Port and conveyor system have been unused for export activities since 2008 and no other industrial activities exist in the region. As such, background and cumulative emissions are expected to be negligible (Atmospheric Solutions 2016). However, conservative background concentrations of the average ambient dust concentrations found in northwest Western Australia have been used during project design to ensure the worst-case scenario is considered. These are 40 µg/m^3 for total suspended particulates, 20 µg/m^3 for particulate matter 10 microns and below, and 7 µg/m3 for particulate matter 2.5 microns and below averaged over 24 hours. These concentrations are based on a number of studies on ambient monitoring of the Kimberley and Pilbara areas, which both experience a higher level of activity than Derby and as such are seen to be a conservative choice in lieu of local data (Atmospheric Solutions 2016b; Appendix 17).

4.3.17 Amenity

Bulk products from the Mine Site will be loaded on to road trains and transported by road to Derby Port for export to overseas markets. Product will be transported using a fleet of five quad road trains, with each road train completing two trips per 12 hour shift. Up to 10 return truck journeys (20 truck movements) per day will occur between the Mine Site and Derby Port, operating 24 hours per day 7 days per week. Approximately 6 km of the transport route is located in residential/commercial areas within Derby, with the remaining 144 km located in unpopulated areas.

The Great Northern Highway forms the longest portion of the transport route to Derby Port (75 km). It is also the main road link between Perth and the Kimberley Region and is the only sealed road connecting Perth with the Northern Territory. As a result, it is used extensively by heavy vehicles.

Loch Street is a continuation of the Derby Highway and is zoned as a 'major highway' according to Derby Town Planning Scheme 5 (SWKD 2003). Derby Highway transitions into Loch Street in the Derby town centre as it passes through residential and commercial areas. Loch Street transitions into Jetty Road at the northwestern most tip of the Derby township, at the intersection with Elder Street. The proposed bulk product transport route is shown in Figure 14.

Existing heavy vehicle movements within the Town of Derby, along Derby Highway and Loch Street, account for between 10% and 18% of all vehicle movements in Derby (MRWA 2015). Approximately 2,220 vehicle movements per day, of which 421 were heavy vehicle movements, occurred along Loch Street east of Ashley Street in 2013/2014. Total vehicle and heavy vehicle movement numbers decreased further from Derby with approximately 580 vehicle movements per day, of which 82 were heavy vehicles occurring on the Derby Highway, north of the Great Northern Highway.

Current and historic daily vehicle movements around Derby and the percentage of these that are heavy vehicle movements are shown in Table 39.

Table 39: Current and Historic Daily Vehicle Movements Around Derby

Road	Location	Total Vehicle Movements / Heavy Vehicle (HV) Movements / % HV				
		2009/10	2010/11	2011/12	2012/13	2013/14
Derby Highway	North of Great Northern Highway	440 / 73 (16.6%)	400 / 55 (13.7%)	560 / 92 (16.5%)	-	580 / 82 (14.1%)
	South of Russ Street	1,640 / 179 (10.9%)	1,980 / 182 (9.2%)	2,330 / 284 (12.2%)	3,000 / 330 (11.0%)	-
	North of Russ Street	-	-	-	-	2,220 / 240 (10.8%)
Loch Street	East of Ashley Street	4,350 / 409 (9.4%)	3,970 / 409 (10.3%)	-	5,350 / 942 (17.6%)	4,050 / 421 (10.4%)

Source: MRWA 2015, '-' No data available. 2014/2015 data not available.

Historically, the Great Northern Highway, Derby Highway, Loch Street, and Jetty Road have been used to transport lead and zinc metal concentrates from the Lennard Shelf Operations, located east of Fitzroy Crossing, to Derby Port. While the Lennard Shelf Lead and Zinc Operations were operational (1997 - 2008), up to 500,000 tonnes per annum of lead and zinc concentrates were transported along the transport route from east of Fitzroy Crossing to Derby Port (MBS 2009).

4.3.17.1 Noise

A noise assessment was undertaken for the Derby Port Development Envelope (WSP Parsons Brinckerhoff 2016a; Appendix 18), in which continuous unattended noise monitoring was conducted simultaneously for seven days between 24 and 31 May 2016 at the Main Roads Western Australia offices on Woodhouse St and the Derby Shire Offices on Loch Street to understand the existing background noise environment. The noise loggers were programmed to record various statistical noise levels over consecutive 15 minute intervals and were used to continuously measure ambient noise, which included all noise sources present at the time (Table 40). The L_{A90} is a good indicator of background noise as it is relatively insensitive to noises that are short term in duration.

Additionally, operator attended monitoring was undertaken at the Jetty Cafe, Fishing Club, Derby Shire Office and Spinifex Hotel in order to understand the composition of the current noise environment and to supplement the unattended noise monitoring data, results of which are presented in (Table 41). All noise measurements were obtained over a sufficient duration to provide a representation of the typical noise emissions.

Table 40: Derby Background Unattended Noise Monitoring Results

Location	Period	L_{A90} (dB)	L_{A10} (dB)	L_{A1} (dB)
Main Roads Office	Night	28	43	50
	Day	41	54	59
	Evening	40	47	55
Shire Office	Night	31	41	51
	Day	38	56	64
	Evening	38	47	59

Table 41: Derby Background Attended Noise Monitoring Results

Location	Time	L_{A90} (dB)	L_{A10} (dB)	L_{Amax} (dB)	Comments
Jetty Cafe	3:05 pm	38	53	72	Cars visiting café and jetty Bird noise
	7:25 pm	34	45	57	Cars visiting café and jetty
Spinifex Hotel	3:35 pm	34	47	72	Occasional bird and traffic
Shire Offices	4:30 pm	43	60	69	Traffic Loch Street Bird noise Plant noise shire offices
	7:50 pm	37	43	65	Traffic Loch Street
Fishing Club	8:05 pm	37	40	69	Insect noise dominant Domestic condenser unit Traffic
	10:00 pm	40	42	45	Insect noise dominant Domestic condenser unit One vehicle pass by

4.3.17.2 Visual Amenity

The wharf is a popular place for fishing and dining at the Derby Wharf Restaurant. With respect to visual amenity at the Derby Port, there are several buildings of single storey currently existing. The site is zoned for industry and includes the wharf, conveyor and existing buildings on the wharf.

The nearest residences are about two kilometres from the Derby Port Development Envelope.

5. ENVIRONMENTAL MANAGEMENT FRAMEWORK

5.1 ENVIRONMENTAL POLICY

Sheffield's Environmental Policy outlines its intentions and commitment to environmental performance. A copy is provided in Appendix 3.

5.2 ENVIRONMENTAL MANAGEMENT SYSTEM

Sheffield is developing an environmental management system (EMS) to facilitate the management of environmental responsibilities for all phases of the project (construction, operation and closure) and to enable continuous improvement of the company's environmental performance. Over the life of the project, the EMS will enable Sheffield to systematically assess and review its environmental impacts, in addition to implementing programs for the management of environmental impacts and obligations.

The Sheffield EMS will be based on AS/NZ ISO 14001:2004 Environmental Management System Standards, which are internationally accepted and include a model for continuous improvement.

EMPs will form the cornerstone of the project's EMS as they will document actions and responsibilities for protection of the environmental values of the Thunderbird Mineral Sand Project.

5.3 ENVIRONMENTAL MANAGEMENT PLANS

Environmental Management Plans (EMPs) underpin the adaptive environmental management approach and will be used for the life of the project to implement the EMS at an operational level. EMPs will cover the design, construction, commissioning, operation phases and maintenance activities of the project. They will identify key environmental issues across the project and provide strategies and plans for managing them effectively. They will also define the legal requirements for the project, identify regulatory permits and licences required for various construction activities and will also govern roles and responsibilities of contractors.

EMPs will be developed and documented through a systematic and consultative process to address environmental factors and risks. Technical input will be sought from a variety of sources including the design and construction contractors, conditions of approvals and legislative requirements and industry standards.

Where there is potential for significant impacts to key environmental factors or there is likely to be significant stakeholder concern, draft Condition EMPs (CEMPs) have been developed in accordance with Environmental Assessment Guideline for Preparation of Management Plans under Part IV of the *Environmental Protection Act 1986* (EPA 2015d) and are provided as drafts to support this Public Environmental Review (PER).

Inclusion of the draft CEMPs for key factors in the PER aims to provide confidence to the EPA and other stakeholders that the project is likely to meet the environmental objective for those factors by providing as much detailed information as possible. The draft CEMPs also provide information which the EPA can use to inform outcome-based conditions where appropriate. CEMPs provided with this PER are listed in Table 42. Non-significant impacts will be managed via policies and procedures documented in the EMS.

It is recognised that aspect specific management plans may be required for the project to satisfy legislative requirements outside of the *EP Act* e.g. A Radiation Management Plan will be required to be submitted to and approved by DMP to satisfy requirements of the *Radiation Safety Management Act* 1975 and the *Mines Safety and Inspection Act 1994*. This focuses on protection of human health, particularly occupational exposure.

Prior to completion of radiation assessments of ore, mine wastes, process residues and products, provision was included in the ESD for inclusion of a Radiation Management Plan as part of the PER. Subsequent completion of the radiation assessment has demonstrated that ore, mine waste, blended process residue to be returned to the mine void and most products will have radiation specific activity concentrations less than 1 Bq/g. In accordance with Australian Radiation Protection and Nuclear Safety Agency (ARPANSA 2005) and International Atomic Energy Agency Safety Guide RS-G-1.7 (IAEA 2004), materials containing naturally occurring radioactive materials (NORMs) are excluded from regulations and considered inherently safe if the specific activity concentrations are below 1 Bq/g (ARPANSA 2005).

Packaged products to be exported from the Port of Broome will be classified as radioactive substances. No products will have a specific activity concentration of NORM greater than 10 Bq/g and as such will not be required to have their transport regulated under the *Radiation Safety Management Act 1975*. Given the low radiation specific activity concentrations and associated low risk to the environment posed by the project, the need for a Radiation Management Plan administered under the *EP Act* that is additional to that required under the *Radiation Safety Management Act 1975* and the *Mines Safety and Inspection Act 1994* is not considered to be warranted and as such has not been included as part of the PER. Management measures relevant to mitigation of potential impacts associated with radiation are documented in Sections 8 to 13 of this PER.

Table 42: Condition Environmental Management Plans Included in PER

Draft CEMP	Key Environmental Factor	Factors/Aspects Addressed
Mine Site Development Envelope		
Mine Closure Plan Appendix 4	Rehabilitation and Decommissioning	Planned, unplanned and temporary closure Post Mining land use Stakeholder engagement Decommissioning Landform re-establishment Revegetation Completion criteria Monitoring
Vegetation Management Plan Appendix 22	Flora and Vegetation	Clearing Management Conservation Significant Flora Weed Management Fire Management
Bilby Management Plan Appendix 23	Terrestrial Fauna	Direct impacts on animals and habitat Indirect impacts on animals and habitat Monitoring
Groundwater Management Plan Appendix 24	Hydrological Processes	Groundwater abstraction Groundwater reinjection Groundwater quality Monitoring
Port Development Envelope		
Port Management Plan Appendix 25	Marine Environmental Quality Amenity	Transport of product Product unloading Product storage Product loading Transhipment Spillage management Radiation management Emissions management (noise and dust) Monitoring

5.4 PRINCIPLES OF ENVIRONMENTAL PROTECTION

The EPA has identified a set of principles for environmental management, which the proponent considered in the Preliminary Feasibility Study. EPA principles are being further considered during the Bankable Feasibility Study (anticipated to be completed in Quarter 4 2016) when the project environmental design standards will be incorporated and implemented in the engineering specifications of the project. Details of how these have been considered in project design are provided in Table 43.

Table 43: Principles of Environmental Protection

Principle	Details	Consideration in Proposal
Precautionary Principle	Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation. In the application of the precautionary principle, decisions should be guided by: • careful evaluation to avoid, where practicable, serious or irreversible damage to the environment • an assessment of the risk-weighted consequences of various options.	A large number of technical investigations were carried out to provide accurate and comprehensive baseline data to allow detailed impact assessment and/or modelling to be carried out with scientific certainty. Studies undertaken for the project are documented in full in Table 14. A risk based approach was undertaken for the development of the project. Project design was amended to avoid, where practicable, serious or irreversible impacts and appropriate management measures have been implemented to minimise residual impacts. This is demonstrated by adjustment of the mining footprint to avoid impact on heritage site buffers determined via consultation with Traditional Owners, removal of a separate borefield originally proposed outside of the current footprint, and reduction of annual throughput. Relevant environmental factors were scoped through the Environmental Scoping Document process for the proposal and involved consultation with EPA and other Decision Making Authorities regarding proposal details and risks.
The principle of intergenerational equity	The present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations.	The project has been designed and will be implemented to ensure that cleared land will be rehabilitated to a condition similar to or better than that of the pre-disturbed land. Closure strategies to achieve this have been developed and are detailed in Sections 3.9 and 12. A Preliminary Mine Closure Plan has been prepared for the Thunderbird Mineral Sands Project. This will be regularly updated in consultation with regulatory authorities, Traditional Owners, the pastoral leaseholder and other stakeholders to ensure that post mining land use is consistent with agreed stakeholder objectives and so that rehabilitation can be progressively implemented. During the life of the project management measures will be implemented to ensure that the environment is protected against potential impacts. Management measures are documented for each Key Environmental Factor in Sections 8.1 to 8.5 and 9.1 to 9.2.

Principle	Details	Consideration in Proposal
The principle of the conservation of biological diversity and ecological integrity	Conservation of biological diversity and ecological integrity should be a fundamental consideration.	Biological diversity has been investigated in detail for this project. Numerous flora and fauna surveys have been carried out for the Mine Site Development Envelope and surrounds and a detailed assessment of the extent and significance of impacts has been completed. The scope of the studies was determined through project scoping, risk assessment and stakeholder consultation. The conservation significant Greater Bilby is present in the area and additional targeted survey work has been carried out to determine the likely impacts on this species and is detailed in Section 13.
Principles relating to improved valuation, pricing and incentive mechanisms	• Environmental factors should be included in the valuation of assets and services. • The polluter pays principle — those who generate pollution and waste should bear the cost of containment, avoidance or abatement. • The users of goods and services should pay prices based on the full life cycle costs of providing goods and services, including the use of natural resources and assets and the ultimate disposal of any wastes. • Environmental goals, having been established, should be pursued in the most cost effective way, by establishing incentive structures, including market mechanisms, which enable those best placed to maximise benefits and/or minimise costs to develop their own solutions and responses to environmental problems.	Sheffield understands that environmental factors should be included in the valuation of assets and services and commits to doing this where appropriate. Sheffield recognises the polluter pays principle and management and mitigation measures as specified in this PER aim to reduce the risk of pollution. Sheffield commits to ongoing mitigation and management measures for the life of the project. Sheffield recognises the need to provide sufficient capital and operating funds to ensure environmental management measures are implemented throughout the project life. Provision has also been made for costs associated with closure and decommissioning and these costs form part of the cost of production. Environmental goals will be pursued in the most cost effective way. As an example, costs and environmental impact associated with power generation and energy use options were considered as part of the Scoping Study and then refined as part of the Preliminary Feasibility Study.
The principle of waste minimisation	All reasonable and practicable measures should be taken to minimise the generation of waste and its discharge into the environment.	All reasonable and practicable measures to minimise the generation of waste and its discharge to the environment will be taken. Sheffield will implement an 'avoid, reduce, re-use, reprocess, recycle, recovery and dispose' hierarchy of waste management approach across all components and phases of the project, in accordance with the objectives of the *Waste Avoidance and Resource Recovery Act 2007.*

6. COMMUNITY AND STAKEHOLDER CONSULTATION

Sheffield has, and will continue to, undertake a vigorous and proactive communication, engagement and consultation program with its stakeholders, government and the broader West Kimberley community. Sheffield engaged stakeholders early in the planning process, primarily in the interests of achieving a collaborative approach and to ensure that local knowledge is considered in the design and management of Thunderbird Mineral Sands Project.

Stakeholder consultation commenced in 2014 with the introduction of the project to the Traditional Owner Groups. This consultation was enhanced throughout the exploration phase of the project; the function was strengthened with the appointment of a Community Relations Advisor and remains an integral part of the current project development phase.

Details of the stakeholder consultation process are provided below, including the identification of consultation objectives, identification of key stakeholders, consultation held to date, and ongoing consultation.

6.1 CONSULTATION OBJECTIVES

The purpose of the engagement and consultation program is to inform and involve affected and interested individual and organisational stakeholders and to address their sentiments and concerns.

The objectives of stakeholder consultation are to:

- Identify key stakeholders and their interests and concerns in relation to environmental impacts.
- Ensure that primary stakeholders understand the project, and that secondary stakeholders receive information and are aware of the project.
- Ensure that interested groups are consulted collaboratively about the project.
- Build open and long-term relationships between Sheffield and stakeholders.
- Allow for meaningful stakeholder input into project design.
- Develop practical mitigation strategies for unavoidable impacts.
- Manage expectations among communities and other stakeholder
- Ensure information provided can be understood and locations for consultation are accessible to all who want to attend.
- Ensure stakeholders have access to information on the proposal in a timely manner.
- Establish clear mechanisms for managing stakeholders' questions, concerns, and complaints/grievances and provide appropriate conflict resolution processes.
- Document formal engagement activities and maintain a relevant database/records management system so that information gained and actions taken in relation to feedback obtained during engagement can be identified.
- Allow for the community's own systems of decision-making to be provided for in engagement timelines. Provide factual, objective information about the project throughout its various stages of definition, environmental assessment and related milestones.

6.2 IDENTIFICATION OF STAKEHOLDERS

Sheffield's stakeholders are those people and organisations who have an impact on, or who are impacted by, the project's development, operations, and activities.

Given the proposed Mine Site Development Envelope is in a remote location, there is no community that will be directly affected. The Derby Port Development Envelope contains the town of Derby which has potential to be directly affected by noise and air emissions associated with transport of product to unloading and export facilities. There may be an increase in activity at the Port of Broome associated with the project, however the haulage road bypassing the town and the existence of appropriate port facilities make community issues less likely.

Stakeholders considered likely to have an interest or role in the environmental impact assessment process are documented in Table 44. The list differentiates between those with a direct involvement or may be subject to direct impacts from the project (Primary Stakeholders) and those with less direct involvement/impact, but likely interest in the project and its environmental impacts (Secondary Stakeholders). Primary stakeholders are those more likely to have a high level of interest in the project and its impacts, and as such they are engaged and consulted more regularly to achieve high levels or understanding. Secondary stakeholders include those who may not be directly affected from the project, but may have a significant influence on the impact assessment process through their community and or political connections. Secondary stakeholders are generally satisfied to be made aware of the project through information dissemination and one-way communication mechanisms.

Differentiating between stakeholder types will ensure engagement is appropriately targeted.

Table 44: Stakeholders Identified for the Thunderbird Mineral Sands Project

Stakeholder Sector	Organisation	Key Interest/s
Primary Stakeholders		
State Government Departments and Agencies	Office of the Environmental Protection Authority	• Administers Part IV of the *Environmental Protection Act 1986* Environmental Impact Assessment via PER process.
	Department of Aboriginal Affairs	• Indigenous and native title requirements. • Heritage, cultural, ethnographic and archaeological sites.
	Department of Mines and Petroleum Mine Safety Inspectorate.	• Administers *Mining Act 1978* and Regulations. • Level 2 Lead Agency Status. • Tenement conditions. • Mining Proposals, Programmes of Work. • Mine Closure Planning including MRF. • Safety in resource sector including radiation management.
	Department of Water	• Provision of licenses to take and abstract water. • Groundwater quality and quantity.
	Department of Environment Regulation	• Administers Part V of the *EP Act*, Industry Regulation and Licensing and *Contaminated Sites Act 2003*.
	Department of Parks and Wildlife	• Administers *Wildlife Conservation Act 1950*. • Flora, fauna and habitat conservation.
	Department of Health	• Radiation management issues. • Environmental health, building and planning compliance.
	Main Roads Western Australia	• Use of public roads (Great Northern Highway).
	Department of Transport	• Owner of Derby Port and Broome Port (Kimberley Ports Authority). • Radiation management during product transport.

Stakeholder Sector	Organisation	Key Interest/s
Commonwealth Government Departments	Department of the Environment and Energy	• Administers *Environment Protection and Biodiversity Conservation Act 1999* • Part 8 (assessment) environmental impact assessments of matters of national environmental significance.
Local Government Authorities	Shire of Derby and West Kimberley	• Use of public roads and infrastructure. • Noise and air quality impacts associated with use of Derby Port. • Use of Derby Port via commercial lease agreement. • Compliance with Port Environmental License conditions.
Indigenous Groups	• Yawuru People • Nyikina Mangala People • Bindinbur Claimants • Mt Jowlanga #2 Claimants • Kimberley Land Council • KRED	• Access to and use of Traditional Owner land. • Indigenous rangers. • Cultural heritage values. • Land management (weeds, feral animals, fire). • Water abstraction and use and impacts. • Native Title rights.
Underlying Land Owner	Mt Jowlaenga pastoral lease.	• Land access approvals. • Land management (weeds, feral animals, fire). • Air and noise emissions at Mine Site. • Interaction with pastoral activities. • Post mining landuse.
Secondary Stakeholders		
Adjacent Land Owners	• Yeeda, Kilto and Country Downs pastoral leases.	• Land management (weeds, feral animals, fire). • Air and noise emissions at Mine Site. • Interaction with pastoral activities. • Post mining landuse. • Water abstraction and use and impacts
Local Government Authorities	Shire of Broome.	• Use of public roads and infrastructure.
Non-Government Organisations, including Environmental Interest Groups	• Environs Kimberley. • Conservation Council of Western Australia (CCWA). • The Wilderness Society. • Wildflower Society of Western Australia. • Australian Conservation Foundation • Loch St, Derby residents • Derby port users • Kimberley Pilbara Cattlemen's Association • Rangelands NRM	• Interest in impacts to flora and fauna, particularly species of conservation significance such as Bilby. • Radiation safety. • Water abstraction and use and impacts on wetlands. • National heritage values. • Noise and dust issues associated with product transport. • Impacts on marine environment due to product export. • Post mining landuse and rehabilitation. • Visual amenity of Mine Site area. • Impacts on ecotourism ventures.
State Government Departments and Agencies	• Department of Fisheries	• Interaction with marine parks and protection of marine wildlife species of conservation significance.
	• Department of Agriculture	• Interaction with Northern National Rangeland Management activities.

Stakeholder Sector	Organisation	Key Interest/s
	Department of Fire and Emergency Services (DFES)	• Fire breaks. • Provision of emergency services.
	Pastoral Lands Board (PLB)	• Pastoral leases, stations.
	Kimberley Ports Authority	• Use of Derby Port and Broome Port via commercial lease agreement.
	Department of Regional Development	• Interaction with regional planning and development
	Kimberley Development Commission	• Interaction with regional planning and development
Commonwealth Government Departments	Australian Border Force	• Export licences and port security permitting
Commercial Projects	Buru Energy	• Cumulative development impacts, particularly on Bilby. • Sharing of scientific knowledge. • Regional approach to impact management.

6.3 PER CONSULTATION/ENGAGEMENT PLAN

6.3.1 Initial Consultation

Consultation with a number of State and Federal Departments and Agencies, Local Government Authorities, and Traditional Owners commenced in 2014/15, with increased consultation occurring during 2016.

To date there have been a number of opportunities for public involvement in the impact assessment process. Opportunities for formal involvement to date have included:

- Comment on the level of assessment appropriate for the project under Part IV of the *EP Act* (October/November 2015). Seven separate submissions were received by the EPA with a common theme recommending use of the PER rather than the API process for project impact assessment.
- Comment on Controlled Action status of the project under the *EPBC Act* (February 2016). No information on submissions was received from the Department of the Environment.

Decision Making Authorities have had an opportunity to provide feedback during an initial project meeting co-ordinated by DMP in its lead agency role (March 2016) and more formally in providing written feedback on the draft Environmental Scoping Document to the OEPA (April/May 2016). The Environmental Scoping Document has been endorsed by the EPA and is available to all stakeholders (July 2016).

A summary of selected stakeholder engagement and consultation actions is listed in Table 45.

Table 45: Summary of Stakeholder Engagement Conducted

Stakeholders	Method	Date
Government stakeholders, State, Federal, Local; elected and administrative	Correspondence	July 2016
Government stakeholders, State, Federal, Local; elected and administrative	More than 100 actions arising from July correspondence; briefings, site visits and request for further information.	July – October 2016
Decision Making Authorities	Site visit to Mine Site and Derby Port	August 2016
Environs Kimberley CEO and Director	Site visit to Mine Site	July 2016
Shire of Derby/ West Kimberley	Site visit to Mine Site	July 2016
Derby community	Community information events (65 attendees)	August 2016
Broome community	Community information events (100 attendees)	August 2016
Residents Loch Street Derby	Door knock project update	August 2016
Marine stakeholders (e.g. Western Australian Fishing Industry Council, licensees fishing, pearls, peak bodies)	Correspondence	August 2016
Derby Port users	Correspondence	September 2016
Derby Port users	Consultation event, Mary Island Fishing Club, Derby (50 attendees)	October 2016
Derby Port users	Publication: Information Update 3 Derby Port	October 2016
Kimberley Pilbara Pastoralists Association	Presentation (water abstraction)	October 2016
Mt Jowleanga Pastoral Lease Holder	Correspondence	Various 2016

A summary of initial stakeholder comments is provided in Table 46. These comments provided guidance as to likely concerns to be raised during ongoing stakeholder engagement and provided focus for future consultation with specific groups/organisations.

Table 46: Summary of Stakeholder Comments

Stakeholder comment	Response
Impact of the project on biodiversity values as a result of land clearing.	Addressed in Section 8.1 and 8.2.
Impact of the project on flora and fauna species of conservation significance. Special mention was specifically made across submissions regarding potential impacts on Bilbies and Northern Quoll.	Addressed in Section 8.1 and 8.2.
Impact of the project on wetlands and groundwater dependant ecosystems.	Addressed in Section 8.1 and 8.3.
Potential impacts associated with acid sulfate soils.	Addressed in Section 4.2.4.5.
Radiation safety issues associated with transport and export of mineral sands products and post mining.	Addressed in Section 10.5 and 11.4.
Impact of water abstraction on local and regional water supplies.	Addressed in Section 8.3.
Impact of the project on marine wildlife and marine conservation areas.	Addressed in Section 11.2.
Impacts of the project on Aboriginal cultural heritage.	Addressed in Section 8.5.
Rehabilitation and post mining land use.	Addressed in Section 12.

6.4 ONGOING STAKEHOLDER CONSULTATION

Stakeholder consultation is ongoing and will continue throughout the approvals process, construction and operational stages of the project. This will include the following levels of engagement:

- Information: Sheffield will continue to publish and distribute information to stakeholders.
- Consultation: The opportunity for two-way exchange of information.
- Participation: Active, multi-directional interaction and more intensive forms of consultation.
- Negotiation: Face-to-face discussion with the intent of reaching agreement on a specific issue.

This PER provides stakeholders with a formal opportunity to provide feedback and comment on the proposal, which will be responded to in the Response to Submissions in the final PER. If approved, Sheffield will continue to implement a Community and Stakeholder Consultation Program during the construction and operations phase of the project. The purpose of this program would be to ensure stakeholders are well informed of project development and to identify, monitor and manage relevant issues raised by stakeholders and the community as a result of the project. This ongoing program will include:

- Continued appointment of a Community Relations Advisor.
- Development and implementation of a Community Relations Program.
- Establishment of a community liaison group to meet quarterly with Sheffield.
- A program of regular events for the community to engage about the project including presentations, town hall and site trip or open-day to inform interested groups about the project and manage expectations.
- A stakeholder consultation register that records all meetings with stakeholders and tracks opinions, views and concerns expressed.
- Project publicity and website that provides the public with project updates and reporting on milestones during construction and operation.
- Annual environmental reporting on the project website, providing the public with detail on environmental performance.

A summary of ongoing stakeholder consultation to be undertaken by Sheffield is provided in Table 47.

Table 47: Proposed Ongoing Stakeholder Consultation

Stakeholder	Consultation Requirements
Mt Jowlaenga No.2 Claim Group	Regular consultation during project feasibility, construction, operation and closure phases.
Nyikina Mangala People	Consultation during project feasibility and construction, operation phases.
Kimberley Traditional Owners	Ongoing consultation during construction, operation phases regarding business and employment opportunities.
West Kimberley community	Ongoing consultation during construction, operation phases regarding business and employment opportunities. Community support and involvement.
DPaW	Report as required during construction, operation and closure. Offsets.
EPA	Report during construction, operation and closure as required by licence conditions and legislation.
DMP	Regular reporting during construction, operation and closure as required by licence conditions and legislation.
DoW	Regular reporting during construction, operation and closure as required by licence conditions and legislation.
Shire of Derby-West Kimberley	Communicate as required regarding activities on Shire of Derby/West Kimberley land.
Shire of Derby/West Kimberley Port	Communicate as required regarding activities on Shire of Derby/West Kimberley Port land.
Shire of Broome/West Kimberley Port	Communicate as required regarding activities within Shire of Broome/ West Kimberley Port land.
MRWA	Construction of intersection with Great Northern Highway. Management and use of Great Northern Highway.

7. ASSESSMENT METHOD

A systematic approach has been used to identify and assess the potential impacts and to determine the mitigation and management measures to prevent or minimise potential impacts. The results of the assessment are presented and discussed in Sections 8 to 13. The assessment approach has been developed to ensure that it addresses the requirements of the *EPBC Act* and *EP Act*. The scope of the assessment was established in the Environmental Scoping Document (ESD) for the Thunderbird Mineral Sands Project, which was approved by the Western Australian EPA on 5 July 2016.

7.1 ENVIRONMENTAL FACTORS AND OBJECTIVES

Environmental factors include physical environmental resources that are valued by society for their ecological, social or economic value and may be impacted by an aspect of a project. Key environmental factors for the project were identified through a scoping process which included:

- Submission of Referral Documentation summarising the results of preliminary environmental investigations.
- Agency consultation.
- Preparation of an ESD by Sheffield in consultation with the EPA.

Environmental objectives are the desired goals that, if met, will indicate that the proposal is not expected to have a significant impact on that part (factor) of the environment. As detailed in the ESD, the preliminary key environmental factors and environmental objectives considered relevant to the proposal are listed in Table 48.

Table 48: Key Environmental Factors

Environmental Factor	Environmental Objective
Mine Site Development Envelope	
Flora and Vegetation	To maintain representation, diversity, viability and ecological function at the species, population and community level.
Terrestrial Fauna	To maintain representation, diversity, viability and ecological function at the species, population and assemblage level.
Hydrological Processes	To maintain the hydrological regimes of groundwater and surface water so that existing and potential uses, including ecosystem maintenance, are protected.
Inland Waters Environmental Quality	To maintain the quality of groundwater and surface water, sediment and biota so that the environmental values, both ecological and social, are protected.
Heritage	To ensure that historical and cultural associations, and natural heritage, are not adversely affected.
Rehabilitation and Decommissioning	To ensure that premises are decommissioned and rehabilitated in an ecologically sustainable manner.
Offsets	To counterbalance any significant residual environmental impacts or uncertainty through the application of offsets.
Derby Port Development Envelope	
Marine Environmental Quality	To maintain the quality of water, sediment and biota so that the environmental values, both ecological and social, are protected.
Amenity	To ensure that impacts to amenity are reduced as low as reasonably practicable.

'Offsets' and 'Rehabilitation and Decommissioning' are considered to be integrating factors by the EPA. These integrating factors were identified as preliminary key environmental factors in the ESD and therefore will be continued to be assessed as such.

The potential impacts and their proposed management on the preliminary key environmental factors for the Mine Site Development Envelope and Derby Port Development Envelope are assessed in Sections 8 and 9 respectively. In addition to preliminary key environmental factors, Matters of National Environmental Significance are identified and discussed separately in Section 13, as required in the ESD.

7.2 OTHER FACTORS

Other environmental factors considered relevant to the proposal, but not of significance to warrant further assessment by the EPA, are listed in Table 49. The potential impacts and proposed management of other environmental factors for the Mine Site Development Envelope and Derby Port Development Envelope are assessed in Sections 10 and 11 respectively.

Table 49: Other Environmental Factors

Environmental Factor	Environmental Objective
Mine Site Development Envelope	
Landforms	To maintain the variety, integrity, ecological functions and environmental values of landforms.
Subterranean Fauna	To maintain representation, diversity, viability and ecological function at the species, population and assemblage level.
Terrestrial Environmental Quality	To maintain the quality of land and soils so that the environment values, both ecological and social, are protected.
Air Quality and Atmospheric Gases	To maintain air quality for the protection of the environment and human health and amenity, and to minimise the emission of greenhouse and other atmospheric gases through the application of best practice.
Human Health	To ensure that human health is not adversely affected.
Port Development Envelope	
Benthic Communities and Habitat	To maintain the structure, function, diversity, distribution and viability of benthic communities and habitats at local and regional scales.
Marine Fauna	To maintain the diversity, geographic distribution and viability of fauna at the species and population levels.
Terrestrial Environmental Quality	To maintain the quality of land and soils so that the environment values, both ecological and social, are protected.
Human Health	To ensure that human health is not adversely affected.

7.3 ASSESSMENT APPROACH

In addition to environmental factors and objectives, the ESD provides a detailed scope of work to be addressed in the Public Environmental Review (this document), including a detailed assessment of impacts and identification of mitigation and management measures. The approach used to assess potential impacts from the project is based on determining the likelihood and consequence following exposure to stressor/s. The approach generally aligns with the processes outlined in Australian Standard/New Zealand Standard (AS/NZS) ISO 31000:2009 Risk Management and Handbook 203:2012 Managing Environment-related Risk. Table 50 lists and defines impact assessment terms used throughout this Public Environmental Review.

Table 50: Impact Assessment Term Definitions

Term	Definition
Consequence	The implication of the potential impact on an environmental or socio-economic factor
Development Envelope	Mine Site: Includes the Mine Site and the Site Access Road. Derby Port: Includes the product storage facility and product export causeway.
Direct impact	Impacts that arise directly from the project e.g. loss of vegetation due to land disturbance.
Factor	Environmental factors include physical environmental resources that are valued by society for their ecological, social or economic value and may be impacted by an aspect of a project.
Hazard	A potential source of harm, or situation with a potential to cause loss or adverse effect.
Indirect impact	Impacts that occur as a result of direct project impacts e.g. a reduction in viability of wildlife populations following removal of habitat.
Inherent impact	Impact before the application of proposed mitigation and management measures.
Likelihood	The probability of a stressor impacting on an environmental factor.
Local/ localised	Includes Development Envelope/s and adjacent or surveyed areas associated with the project
Long term	Longer than 10 years.
Medium term	Longer than two years, but fewer than 10 years.
Permanent	Impacts that arise from irreversible changes in conditions caused by the project, such as alteration of the landscape by mining.
Potential impact	Interaction of a stressor with an environmental or socio-economic factor that can reasonably be expected or is likely to occur in the lifetime of the project.
Regional	Terrestrial: Includes a broader land area, including the Dampier Peninsula. Marine: WA Coastal Waters and coastline between Beagle Bay and Camden Sound, including King Sound.
Residual impact	Impact remaining after the application of proposed mitigation and management measures.
Short term	Fewer than two years.
Stressor	A source of potential harm, or a situation with a potential to cause loss or adverse effects.

7.3.1 Consequence of Potential Impacts

A number of aspects were considered in determining the consequence of each potential impact, including:

- Type of impact (direct or indirect).
- Geographic extent, size and scale.
- Duration, frequency, reversibility of the potential impact.
- Whether the potential impacts are from planned or unplanned events.
- Sensitivity of the receptor/resource and the value of the receptor/resource and whether impacts are likely to be from planned or unplanned events.

The definitions for these aspects are described in Table 51.

Table 51: Environmental Impact Consequence Definitions

Incidental	Minor	Moderate	Major	Severe
Key Environmental Factors				
Terrestrial Flora and Vegetation				
Localised and short term decrease in health, abundance and structure of vegetation communities that are well represented in the region.	Localised and medium term decrease in health, abundance and structure of vegetation communities that are well represented in the region.	Localised and long term decrease in health, abundance and structure of vegetation communities that are not well represented in the region.	Widespread and medium term decrease in health, abundance and structure of vegetation communities that are not well represented in the region.	Permanent loss of vegetation communities that are not well represented in the region.
No direct loss of conservation significant flora in Development Envelope although increased stress incurred through indirect or induced processes.	Minor, localised loss of conservation significant flora either through direct, indirect or induced processes.	Regional loss of conservation significant flora with no impacts on species survival.	Project places significant pressure on continued survival of conservation significant species.	Project results in extinction of conservation significant species on a regional scale.
Manageable, localised weed infestation that does not result in competition with native species.	Manageable, localised weed infestation that results in minor competition with native species.	Localised weed infestation that results in competition with native species requiring considerable management/control measures.	Regional weed infestation that results in competition with native species requiring extensive management/control measures.	Uncontrollable regional weed infestation that results in competition with native species.
Revegetation				
Revegetation progress is slightly impeded. Achievement of species diversity, vegetation coverage, and plant survival approaches predicted levels (with consideration of natural variability and conditions).	Revegetation progress experiences minor impediment. Localised and isolated failure to reach species diversity, vegetation coverage, and plant survival targets.	Revegetation progress experiences moderate impediment. Localised and permanent, or widespread failure to reach species diversity, vegetation coverage, and plant survival targets.	Revegetation progress experiences major impediment. Widespread and permanent failure to reach species diversity, vegetation coverage, and plant survival targets.	Revegetation is deemed unsuccessful. Cleared land remains in a denuded state.

Incidental	Minor	Moderate	Major	Severe
Terrestrial Fauna				
Localised and short term loss of habitat (including that of conservation significant species) that is well represented in the region, overall habitat area remains intact with minimal fragmentation.	Localised and medium term loss of habitat (including that of conservation significant species) that is well represented in the region, some short term habitat fragmentation	Localised and permanent or widespread and long term loss of habitat (including that of conservation significant species) that is not well represented in the region, medium term habitat fragmentation.	Permanent and widespread loss of habitat (including that of conservation significant species) that is not well represented in the region, permanent habitat fragmentation.	Permanent loss and fragmentation of habitat (including that of conservation significant species) that is not well represented in the region.
Some displacement of fauna that has no lasting effects on population viability or abundance.	Some displacement of fauna that has short term effects on population viability or abundance.	Displacement of fauna that has medium term effects on population viability or abundance	Displacement of fauna that puts populations at risk of local extinction	Fauna displacement leads to extinction of species on a regional scale.
No measurable impacts to behaviour of fauna in local area.	Short term impact to behaviour of fauna in local area.	Medium term impact to behaviour of fauna in local area.	Long term and widespread impact to behaviour of fauna.	Permanent change to behaviour of fauna in the regional area.
Localised and short-term decrease in fauna abundance (including conservation significant fauna) occurring in the Development Envelope.	Localised and long-term or widespread, and short-term decrease in fauna abundance (including conservation significant fauna) within the Development Envelope.	Localised and irreversible or widespread and long-term decrease in fauna abundance (including conservation significant fauna).	Significant, widespread, and persistent decrease in fauna abundance (including conservation significant fauna).	Permanent loss of a significant portion of fauna population (including conservation significant fauna).
Localised and short term loss of Short Range Endemic (SRE) habitat that is well represented in the region, loss of SREs that has no effect on population viability or abundance.	Localised and medium term loss of SRE habitat that is well represented in the region, loss of SREs that has short term effects on population viability or abundance.	Localised and permanent or widespread and long term loss of SRE habitat that is not well represented in the region, loss of SREs that has medium term effects on population viability or abundance.	Permanent and widespread loss of SRE habitat that is not well represented in the region, loss of SREs that puts populations at risk of local extinction.	Permanent loss of SRE habitat that is not well represented in the region, loss of SREs leads to extinction of species on a regional scale.
Minor increase in pest species numbers, but does not result in impacts to the population viability or abundance of native species.	Minor increase in pest species numbers, resulting in localised impacts to the population viability or abundance of native species.	Major increase in pest species numbers, resulting in widespread impacts to the population viability or abundance of native species.	Pest species introduced and populations expand into the regional area resulting in long term exclusion of native species.	Pest species introduced and populations expand into the regional area resulting in permanent exclusion of native species.

Incidental	Minor	Moderate	Major	Severe
Hydrological Processes and Inland Waters Environmental Quality				
Surface Water				
Minor change to surface water quality within the project area that does not change its ability to be used by livestock and fauna	Minor change to surface water quality within the project area and downstream watercourses that does not affect its use by livestock and fauna.	Moderate change to surface water quality within the project area and downstream watercourses that affects its use by livestock and fauna in the short term.	Decline in surface water quality in the project area and downstream watercourses that prevents medium to long term use by livestock and fauna.	Decline in surface water quality on a regional scale that prevents long term use by livestock and fauna.
Short term changes to local water volumes that do not affect beneficial uses, including livestock and fauna.	Medium term changes to local water volumes that do not affect beneficial uses, including livestock and fauna.	Short term changes to regional water volumes that affect beneficial uses, including livestock and fauna.	Medium term changes to regional water volumes that affect beneficial uses, including livestock and fauna.	Project causes permanent loss of surface water resources that affects livelihoods and/or survival of communities.
Groundwater				
Minor, localised change to groundwater quality that does not change its ability to be used by beneficial uses, including livestock, fauna, groundwater dependent ecosystems and subterranean fauna.	Short term localised decline in groundwater quality that affects beneficial uses, including livestock, fauna, groundwater dependent ecosystems and subterranean fauna.	Medium term localised decline in groundwater quality that affects beneficial uses, including livestock, fauna, groundwater dependent ecosystems and subterranean fauna.	Short to medium term regional decline in water quality that prevents beneficial uses, including livestock, fauna, groundwater dependent ecosystems and subterranean fauna.	Long term regional decline in water quality that prevents beneficial uses, including livestock, fauna, groundwater dependent ecosystems and subterranean fauna.
Minor changes to local groundwater levels/availability that do not affect beneficial uses, including livestock, fauna, groundwater dependent ecosystems and subterranean fauna.	Local changes to groundwater levels/availability that do not affect beneficial uses, including livestock, fauna, groundwater dependent ecosystems and subterranean fauna.	Local changes to groundwater levels/availability that affect beneficial uses, including livestock, fauna, groundwater dependent ecosystems and subterranean fauna in the short to medium-term.	Regional changes to groundwater levels/availability that affect beneficial uses including livestock, fauna, groundwater dependent ecosystems and subterranean fauna in the medium term.	Regional changes to groundwater levels/availability that affect beneficial uses, including livestock, fauna, groundwater dependent ecosystems and subterranean fauna in the long term.

Incidental	Minor	Moderate	Major	Severe
Heritage				
No loss or disturbance of physical or cultural heritage within local area.	Loss or disturbance of non-significant physical or cultural heritage within local area in agreement with traditional owners and compliant with relevant legislation.	Loss or disturbance of significant physical or cultural heritage in agreement with traditional owners and compliant with relevant legislation.	Loss or disturbance of significant physical or cultural heritage that requires significant compensation compliant with relevant legislation.	Loss or disturbance of significant physical or cultural heritage not in agreement with traditional owners that requires significant compensation and is not compliant with relevant legislation.
Marine Environmental Quality				
Short term impacts to quality of water, sediment or biota that do not affect ecological and social values. Restricted to immediate vicinity of project disturbance.	Short to medium term, local impacts to quality of water, sediment or biota that do not affect ecological and social values.	Medium term, local impacts to quality of water, sediment or biota that affect ecological and social values.	Short term, regional impacts to the quality of water, sediment or biota that affects ecological and social values.	Long term, regional impacts to the quality of water, sediment or biota that results in a reduction in ecological and social values.
Amenity				
Minor, short term and infrequent loss of amenity within the local area. Total Suspended Particles (TSP) and dust deposition guideline levels are not exceeded for sensitive receptors.	Minor and short term, but frequent, loss of amenity within the local area. TSP and dust deposition guideline levels may be exceeded for sensitive receptors, but this rarely happens.	Medium term and frequent decreases in amenity within a local area. TSP and dust deposition guideline levels are exceeded occasionally for sensitive receptors.	Medium term decline in amenity within a regional area. TSP and dust deposition guideline levels are exceeded frequently for sensitive receptors.	Long term decline in amenity over a regional area. TSP and dust deposition guideline levels are exceeded almost constantly for sensitive receptors.
Noise levels remain below relevant guideline values at all locations.	Noise levels remain below relevant guideline values at most locations but some non-sensitive receptors impacted by minor exceedances.	Occasional exceedance of relevant guideline values at sensitive receptor locations.	Frequent exceedance of relevant guideline values at sensitive receptor locations.	Continuous exceedance of relevant guideline values at sensitive receptor locations.

Incidental	Minor	Moderate	Major	Severe
Other Factors				
Landforms				
Post mining landforms are consistent with their surroundings.	Post mining landforms are generally consistent with their surroundings with minor variations in elevation, profile and vegetation.	Post mining landforms are generally consistent with their surroundings but show distinguishable variation in elevation, profile and vegetation.	Post mining landforms are inconsistent with their surroundings with notable differences in elevation, profile and vegetation.	Post mining landforms are inconsistent with their surroundings, represented by significant differences in elevation, profile and vegetation.
Post mining landforms are stable.	Post mining landforms are stable but may experience minor erosion, such as rilling.	Post mining landforms are generally stable, but may experience moderate erosion, such as limited gullying.	Post mining landforms are unstable, with significant erosion, such as tunnelling and gullying, and subsidence.	Post mining landforms fail (e.g. TSF embankment failure), with extensive ongoing management issues.
Subterranean Fauna				
Short term loss to the representation, diversity, viability and ecological function of subterranean fauna species, populations or assemblages in the Development Envelope.	Medium term loss to the representation, diversity, viability and ecological function of subterranean species, populations or fauna assemblages in the local area.	Long term loss to the representation, diversity, viability and ecological function of subterranean fauna species, populations or assemblages in the local area.	Short or medium term loss to the representation, diversity, viability and ecological function of subterranean species, populations or fauna assemblages in the regional area.	Permanent loss to the representation, diversity, viability and ecological function of subterranean species, populations or fauna assemblages in the regional area.
Terrestrial Environmental Quality				
Loss of soil resources has short term impact on associated environmental values within Development Envelope.	Loss of soil resources has medium term impact on associated environmental values on a local scale.	Loss of soil resources has long term impact on associated environmental values on a local scale.	Loss of soil resources resulting in a short to medium term impact on associated environmental values on a regional scale.	Loss of soil resources that has a permanent impact on associated environmental values on a regional scale.
Land contamination within Development Envelope, easily treatable in short term and does not result in adverse impacts on associated environmental values.	Land contamination localised and treatable in medium term. Does not result in adverse impacts on associated environmental values.	Localised land contamination that results in adverse impacts on associated environmental values in the short to medium term.	Land contamination on a regional scale resulting in adverse impacts on associated environmental values requiring medium to long term management.	Land contamination on a regional scale resulting in permanent damage with severe environmental and socioeconomic disruption.

Incidental	Minor	Moderate	Major	Severe
Air Quality and Atmospheric Gases				
Emission levels remain below relevant National Environmental Protection Measures (NEPM) values at all receptor locations.	Emission levels remain below relevant NEPM values at most locations but some non-sensitive receptors impacted by minor exceedances.	Occasional exceedance of relevant NEPM values at sensitive receptor locations.	Frequent exceedance of relevant NEPM values at sensitive receptor locations.	Continuous exceedance of relevant NEPM values at sensitive receptor locations.
Benthic Communities and Habitat				
Short term changes restricted to immediate vicinity of project disturbance to the structure, diversity and distribution of benthic habitats and communities.	Short to medium term changes restricted to within 10 km of project disturbance to the structure, diversity and distribution of benthic habitats and communities.	Long term changes restricted to within 10 km of project disturbance to the structure, diversity and distribution of benthic habitats and communities.	Short to medium term, regional changes relating to the structure, diversity and distribution of benthic habitats and communities.	Long term, regional changes relating to the structure, diversity and distribution of benthic habitats and communities.
Marine Fauna				
Short term impact to conservation significant fauna habitat within the Port Development Envelope or immediate area of disturbance, overall habitat area remains intact.	Medium term or minor loss of conservation significant fauna habitat within 10km of project disturbance.	Long term or moderate loss of conservation significant fauna habitat within 10 km of project disturbance.	Long term or moderate loss of conservation significant fauna habitat in the regional marine environment.	Permanent loss of conservation significant fauna habitat in the regional marine environment.
Death of an individual animal of conservation significant species that does not impact on population's ability to survive locally.	Death of several animals of conservation significant species that does not impact on population's ability to survive locally.	Death of multiple animals of conservation significant species that compromises species ability to survive locally.	Death of multiple animals of conservation significant species that compromises species ability to survive regionally.	Death of multiple animals of conservation significant species that results in a regional extinction.
Short term disruption of marine fauna or minor disruption to breeding patterns and/or behaviour within the immediate area of project disturbance that does not affect population health or survival.	Short to medium term disruption of marine fauna or minor disruption to breeding patterns and/or behaviour within the immediate area of project disturbance that affects local population health or survival.	Short to medium term disruption to marine fauna breeding patterns and/or behaviour within 10km of project disturbance that affect local population health or survival.	Medium to long term disruption to marine fauna breeding patterns and/or behaviour in the regional marine environment that compromise population health and survival.	Permanent change to marine fauna breeding patterns and/or behaviour that affect species survival in the regional marine environment.

Incidental	Minor	Moderate	Major	Severe
Human Health				
Infrequent, perceptible increases in noise above baseline conditions within Development Envelope that do not affect the well-being of receptors.	Infrequent, perceptible increases in noise above baseline conditions in the local area that occasionally disrupts the well-being of receptors.	Occasional increases in noise above baseline conditions in the regional area that disrupts the well-being of receptors.	Frequent increases in noise above baseline conditions in the regional area that significantly disrupts the wellbeing of receptors.	A continuous increase in noise above baseline conditions in the regional area that significantly impacts the wellbeing of receptors.
Isolated, infrequent acute health impacts within the Development Envelope attributable to project emissions.	Isolated, infrequent acute health impacts in the local area attributable to project emissions.	Frequent acute health issues in the local area attributable to project emissions.	Chronic community health issues in local area attributable to project emissions.	Chronic community health issues in regional area attributable to project emissions.

7.3.2 Likelihood of Potential Impacts

Likelihood is the probability of a stressor impacting on an environmental factor, after the application of mitigation and management measures. Where practicable, likelihood was quantified based on quantitative information or data. Definitions for likelihood are presented in Table 52.

Table 52: Likelihood Definitions

Descriptor	Explanation
Rare /Rarely	May occur in exceptional circumstances (would be considered highly unusual); may occur in the next 30 -40 years (<5% per year).
Unlikely	Not likely to occur; may occur within the next 10- 20 years (5%-10% probability).
Possible /Possibly	May occur within 5-10 years (10%-50% probability).
Likely	Known to occur or has occurred in the past; is likely to occur in the next 24-36 months (50-80% probability).
Almost Certain / Almost Certainly	Expected to occur in the next 12-24 months (80-100% probability).

7.3.3 Residual Impact

The residual impacts were determined by assessing the likelihood and consequence when mitigation and management measures are applied. The level of residual impact was determined using the matrix shown in Table 53.

Where high or extreme residual impacts remained after mitigation, further options were examined in consultation with the project team. This process continued until impacts were considered to be reduced.

Table 53: Impact Assessment Matrix

Likelihood	Impact Consequence				
	Incidental	Minor	Moderate	Major	Severe
Rare	Low	Low	Medium	Medium	High
Unlikely	Low	Low	Medium	High	High
Possible	Low	Medium	Medium	High	Extreme
Likely	Low	Medium	High	Extreme	Extreme
Almost Certain	Medium	Medium	High	Extreme	Extreme

Residual impacts derived from use of this matrix are used in decision making according to the following categories:

- **'Low' residual impacts** are not considered to be of concern for decision making.
- **'Medium' residual impacts** are not considered to require specific attention in the decision on approval of the project and adequate mitigation is considered achievable using reasonable mitigation and management measures. Monitoring may be needed to confirm that impacts do not exceed predicted levels.
- **'High' residual impacts** are considered to require careful attention in decision making and specific mitigation and monitoring measures should be identified to ensure adverse impacts are as low as reasonably practicable or the likelihood of occurrence is significantly reduced or that beneficial impacts are delivered.

- **'Extreme' residual impacts** occur when a significant change from baseline is predicted that exceeds legal limits and accepted standards. These warrant substantial consideration, when compared with other environmental, social or economic costs and benefits in making decisions on whether or not to allow a project to go ahead. Specific mitigation measures and monitoring should be identified to ensure impacts are well managed and the likelihood of occurrence is reduced.

If the impact assessment process has been successful, the majority of residual impacts should be of no more than medium residual impact. High or extreme residual impacts should only arise where there are special circumstances preventing their mitigation, and management measures should aim to reduce the likelihood of these events occurring. There should be no residual impacts that are extreme unless they are being addressed by offsets.

7.4 SCREENING OF IMPACTS

During the assessment phase, a number of stressors that were included in the Environmental Scoping Document were screened out from further assessment, as they were either identified as being not likely to occur or were unlikely to have any discernible consequence on any factor different to background levels. These factors and stressors are outlined in in following impact assessment sections, as well as an explanation for excluding them from further assessment.

7.5 MITIGATION AND MANAGEMENT MEASURES

Impact assessment is designed to ensure that decisions on projects are made in full knowledge of potential impacts on the environment and society. A vital step within the process is the identification of measures that can be taken to ensure adverse impacts are as low as reasonably practicable and positive impacts are maximised. This is achieved by undertaking an assessment to identify where significant impacts could occur and then working with the wider project team to identify technically and financially feasible ways of mitigating and reducing risk.

When developing the mitigation and management measures for this project, the following hierarchy of control was considered:

- **Avoidance**: Significant avoidance and minimisation measures have been incorporated into decision making and Mine Site design.
- **Minimisation**: Measures that minimise an impact (for example by storing hydrocarbons in impermeable storage areas).
- **Reduction**: Measures that reduce or eliminate the impact of an activity (for example implementing measures to reduce dust emissions from vehicle travel on unsealed roads).
- **Correction**: Measures that correct or rectify an impact (for example via restoration, repair, or rehabilitation).
- **Compensation**: Measures to compensate for impacts from project activities (for example by replacing lost or damaged environmental components in kind or with agreed substitute resources).

Many of the mitigation and management measures included in this assessment will be included in the Environmental Management Plans associated with the implementation of the project. These plans will include monitoring programs, which will be used to verify impact predictions and the effectiveness of the mitigation and management measures. An adaptive management framework will exist during implementation, and plans will be updated as required according to new information or changing circumstances, experiences and lessons.

7.6 DEALING WITH UNCERTAINTY

Impact assessments often include a level of uncertainty, which exists due to a number of factors, including limited understanding of complex systems and factors that cannot be fully understood due to limited available data. The impact assessment was based on current knowledge, available data from existing and commissioned studies and professional judgement.

Where identified impacts had a level of uncertainty, the approach has been to take a conservative and cautious view of the potential impacts of the project. Several areas of additional study shall be undertaken during detailed design, construction and operations. These are identified and will be used to inform the development of detailed mitigation and monitoring plans.

8. ENVIRONMENTAL IMPACT ASSESSMENT - KEY ENVIRONMENTAL FACTORS - MINE SITE DEVELOPMENT ENVELOPE

Key environmental factors for the Mine Site Development Envelope comprise the following:

- Flora and Vegetation.
- Terrestrial Fauna.
- Hydrological Processes.
- Inland Waters Environmental Quality.
- Heritage.
- Rehabilitation and Decommissioning (Integrating Factor).
- Offsets (Integrating Factor).

Potential impacts for the key environmental factors are detailed in Sections 8.1 to 12. Offsets are addressed separately in Section 14.

8.1 FLORA AND VEGETATION

The EPA's objective in relation to flora and vegetation is "*to maintain representation, diversity, viability and ecological function at the species, population and community level*".

8.1.1 Key Statutory Requirements, Environmental Policy and Guidance

Vegetation and flora are protected under Commonwealth and State legislation, primarily governed by three Acts:

- *Environment Protection and Biodiversity Conservation Act 1999* (Cth).
- *Wildlife Conservation Act 1950* (WA).
- *Environmental Protection Act 1986* (WA).

In addition to Commonwealth and State legislation, the following policy and guidance statements were considered in the impact assessment for flora and vegetation:

- EPA Position Statement No. 2, Environmental Protection of Native Vegetation in Western Australia (EPA 2000).
- EPA Position Statement No. 3, Terrestrial Biological Surveys as an Element of Biodiversity Protection (EPA 2002).
- EPA Guidance Statement No. 51, Terrestrial Vegetation and Flora Surveys for Environmental Impact Assessment in Western Australia (EPA 2004c).
- EPA and DPaW Technical Guide – Flora and Vegetation Surveys for Environmental Impact Assessment (EPA and DPaW 2015).
- Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) Guide G-1, Radiation Protection of the Environment (ARPANSA 2015).

8.1.2 Assessment of Potential Impact

Clearing for the project in the Mine Site Development Envelope will directly impact flora and vegetation, resulting in:

- **Loss of native vegetation communities**.
- **Loss of conservation significant flora**.

Potential indirect impacts to flora and vegetation resulting from the project within the Mine Site Development Envelope include:

- **Dust generated from construction and mining activities resulting in reduced vegetation health and condition –** construction and mining activities and use of the Site Access Road may generate dust that impacts vegetation health.
- **Increased presence of weeds resulting in reduced native vegetation cover and diversity** – weeds may be introduced to the area or spread by movement of equipment and nutrient loading from land irrigation of treated wastewater may favour weed growth.
- **Modification of surface water flows resulting in loss or reduced health and condition of native vegetation –** surface water flows may be modified due to pipelines or other landscape modifications, and vegetation may be inundated or receive reduced amounts of water.
- **Groundwater abstraction resulting in loss or reduced health and condition of groundwater dependent ecosystems (GDEs).**
- **Altered fire regimes resulting in loss or reduced health and condition of native vegetation**.

Other potential impacts were screened out from further assessment (Section 7.4) as they were either assessed as not likely to occur or were unlikely to have any discernible consequence on any factor different to background levels:

Stressor	Justification for Exclusion
Radiation exposure to native vegetation resulting in loss or reduced health and condition of native vegetation	The vast majority (98%) of all process waste streams is from ilmenite processing or initially rejected sand/slimes material with low activity (0.39 Bq/g, see Appendix 21). Material with activity less than 1 Bq/g based on composition of Sheffield waste materials does not trigger the Tier 1 Environmental screening criteria of 10 µGy/h using the ERICA software assessment (ARPANSA 2015) for terrestrial flora. Sheffield commit to mixing and co-disposal of wastes to <1 Bq/g (combined activity of reject material from processing c.a. 0.74 Bq/g). Backfill areas will be monitored to ensure radiation levels are within environmental screening criteria (10 µGy/h) or established pre-mining background levels. The inherent use of wet slurries for transport of mine waste back to the void minimises potential for dust emissions of higher activity material.

The assessed likelihood, consequence and residual impact (as per Section 7.3), is provided below for each potential impact.

8.1.2.1 Clearing Resulting in Loss of Vegetation Communities or Conservation Significant Species

A total of 2,215.3 ha are required to be cleared during the project life, with a further 57.3 ha already having been cleared (Mt Jowlaenga Road). Clearing for permanent infrastructure is 593.3 ha, with the remainder of the clearing to be undertaken progressively as the mining excavation advances. At any given time, the clearing footprint for the mineral deposit area will be about 200 ha.

Clearing Resulting in Loss of Vegetation Communities

A total of 15 vegetation communities occur within the wider survey area of the Mine Site (Table 54 and Figure 28). There are no TECs or PECs within or adjacent to the Mine Site Development Envelope, with the nearest approximately 50 km away.

Two vegetation communities, W6 and W8 (including W8a), were considered to be most representative of the Mine Site Development Envelope, and accounted for the majority (86%) of the surveyed area (Figure 28). These communities consist of Pindan vegetation (low sparse Eucalypt woodlands over *Acacia tumida* shrubland over *Triodia/Chrysopogon* grasslands), which are common and widespread throughout the broader Kimberley region (Mattiske 2016). As shown in Table 54, seven of the 15 identified communities will not be impacted by the project and all communities proposed to be cleared are represented outside the Mine Site Development Envelope. The largest proposed impact is to vegetation community W8 at 15.6% (Table 54).

It is anticipated that clearing will 'Almost Certainly' result in a localised and medium term decrease in abundance and structure of vegetation communities. The potential residual impact from clearing on vegetation communities, after implementation of management measures, is assessed as 'Medium'.

Impact	Consequence	Likelihood	Residual Impact
Clearing resulting in loss of vegetation communities	Minor	Almost Certain	Medium

Table 54: Proposed Disturbance at the Mine Site Development Envelope for Each Defined Vegetation Community

Code	Vegetation Community Description	Mapped Area (ha)[1]	Proposed Clearing Area (ha)	Proposed Clearing Area (%)
Woodlands				
W1	*Melaleuca viridiflora*, *Melaleuca alsophila* and *Eucalyptus tectifica* low sparse woodland over *Bauhinia cunninghamii*, *Carissa lanceolata* and *Atalaya hemiglauca* tall sparse shrubland over *Ectrosia schultzii*, *Eriachne sulcata* and *Cyperus conicus* low sparse grassland on grey-white to light brown sandy soils in drainage channels and low lying drainage areas.	127.5	1.9	1.5%
W2	*Eucalyptus tectifica* mid open woodland over *Acacia plectocarpa* subsp. *plectocarpa* and *Grevillea pyramidalis* subsp. *pyramidalis* tall sparse shrubland over *Aristida holathera* subsp. *latifolia*, *Eriachne obtusa* and *Xerochloa laniflora* mid sparse grassland on light brown clayey sands in low lying drainage areas.	3.1	0.0	0.0%
W3	*Corymbia dendromerinx, Eucalyptus tectifica* and *Corymbia greeniana* mid open woodland over *Dolichandrone heterophylla*, *Dodonaea hispidula* var. *arida* and *Grevillea pyramidalis* subsp. *pyramidalis* mid sparse shrubland over *Triodia caelestialis* (P3), *Triodia schinzii* and *Eriachne obtusa* mid sparse hummock grassland on orange-brown clayey sands on flats and drainage areas.	35.7	0.0	0.0%
W4	*Corymbia dendromerinx* mid open woodland over *Terminalia canescens*, *Calytrix exstipulata* and *Wrightia saligna* tall sparse shrubland over *Triodia caelestialis* (P3), *Triumfetta albida* and *Polycarpaea longiflora* mid open tussock grassland on brown sandy clay soils on mid-slopes to ridges of hills with sandstone outcropping.	272.0	0.0	0.0%
W5	*Corymbia dendromerinx* mid open woodland over *Grevillea pyramidalis* subsp. *pyramidalis*, *Terminalia canescens* and *Waltheria indica* mid sparse shrubland over *Triodia caelestialis* (P3), *Sorghum plumosum* and *Hybanthus enneaspermus* subsp. *enneaspermus* low sparse tussock grassland on pale brown to orange-brown sandy clay loam soils on slopes and broad flat hill tops with sandstone outcropping.	234.5	0.1	0.1%
W6	*Eucalyptus tectifica*, *Bauhinia cunninghamii* and *Brachychiton diversifolius* subsp. *diversifolius* mid open woodland over *Carissa lanceolata* and *Dolichandrone heterophylla* mid sparse shrubland over *Triodia caelestialis* (P3), *Triodia schinzii* and *Eriachne obtusa* mid sparse tussock grassland on pale brown to grey brown sandy clay loams on flats.	3,432.0	89.9	2.6%
W7	*Brachychiton diversifolius* subsp. *diversifolius* and *Eucalyptus tectifica* low open woodland over *Bauhinia cunninghamii, Acacia plectocarpa subsp. plectocarpa* and *Melaleuca viridiflora* tall sparse shrubland over *Triodia caelestialis* (P3), *Triodia schinzii* and *Aristida holathera var. holathera* mid sparse hummock grassland on pale orange-grey clayey sands on flats.	101.6	3.7	3.6%
W8	*Erythrophleum chlorostachys*, *Brachychiton diversifolius* subsp. *diversifolius* and *Corymbia greeniana* mid open woodland over *Acacia tumida* var. *tumida*, *Bauhinia cunninghamii* and *Dodonaea hispidula* var. *arida* tall sparse shrubland over *Triodia caelestialis* (P3), *Triodia schinzii* and *Eriachne obtusa* mid sparse tussock grassland on orange brown to red fine sandy soils on flats.	12,834.5	2001.2	15.6%

Code	Vegetation Community Description	Mapped Area (ha)[1]	Proposed Clearing Area (ha)	Proposed Clearing Area (%)
W8a	*Erythrophleum chlorostachys, Brachychiton diversifolius* subsp. *diversifolius* and *Corymbia greeniana* mid open woodland over *Acacia tumida* var. *tumida, Bauhinia cunninghamii* and *Dodonaea hispidula* var. *arida* tall sparse shrubland over *Triodia caelestialis (P3), Triodia schinzii* and *Eriachne obtusa* mid sparse tussock grassland on orange-brown to red fine sandy soils in swale area subject to seasonal inundation.	36.9	0.7	1.9%
W9	*Corymbia dendromerinx* low open woodland over *Grevillea pyramidalis* subsp. *pyramidalis*, *Microstachys chamaelea* and *Terminalia canescens* mid sparse shrubland over *Chrysopogon sp.* (*C. fallax* or *C. pallidus*), *Glycine tomentella* and *Sorghum plumosum* mid sparse grassland on orange-brown sandy clay with sandstone rocks and outcropping on hills.	67.9	0.0	0.0%
W10	*Corymbia greeniana, Corymbia dendromerinx* and *Brachychiton diversifolius subsp. diversifolius* low open woodland over *Grevillea pyramidalis* subsp. *pyramidalis*, *Grevillea refracta* subsp. *refracta* and *Terminalia canescens* tall sparse shrubland over *Triodia caelestialis* (P3), *Solanum cunninghamii* and *Aristida hygrometrica* mid open tussock grassland on orange-brown clayey sands with occasional sandstone or ironstone rocks on flats and slopes associated with drainage areas.	964.3	88.4	9.2%
W11	*Corymbia zygophylla* low open woodland over *Acacia tumida* var. *tumida* and *Erythrophleum chlorostachys* tall sparse shrubland over *Triodia schinzii* and *Microstachys chamaelea* low sparse grassland on orange-brown clayey sands on flats and slopes.	40.9	0.0	0.0%
W12	*Corymbia greeniana*, *Eucalyptus tectifica* and *Corymbia dendromerinx* mid open woodland over *Dolichandrone heterophylla*, *Bauhinia cunninghamii* and *Acacia tumida* var. *tumida* tall sparse shrubland over *Triodia caelestialis* (P3), *Triodia schinzii* and *Eriachne obtusa* mid sparse tussock grassland, on brown clayey sands on flats and drainage channels.	519.8	29.0	5.6%
W13	*Brachychiton diversifolius* subsp. *diversifolius, Erythrophleum chlorostachys* and *Corymbia dendromerinx* mid open woodland over *Grevillea refract* subsp. *refracta*, *Acacia monticola* and *Microstachys chamaelea* tall sparse shrubland over *Corchorus sidoides*, *Goodenia sepalosa* subsp. *sepalosa* and *Pterocaulon paradoxum* low sparse forbland on orange-brown clayey sands on flats.	25.1	0.0	0.0%
W14	*Eucalyptus camaldulensis* mid open woodland over *Melaleuca viridiflora, Melaleuca alsophila* and *Bauhinia cunninghamii* mid sparse shrubland over *Ectrosia schultzii, Eriachne sulcata* and *Fimbristylis littoralis* low sparse grassland on grey to light brown sandy clay soils in drainage channels.	13.6	0.0	0.0
Shrubland				
S1	*Acacia tumida* var. *tumida* low sparse shrubland over *Waltheria indica* and *Bauhinia cunninghamii* low isolated shrubs over *Ectrosia schultzii*, *Eriachne obtusa* and *Corchorus pumilio* low sparse grassland on pale grey sandy clay loam soils on flats and slopes.	58.9	0.4	0.7%

Notes: 1 – Source Mattiske 2016

Clearing Resulting in Loss of Conservation Significant Flora

A total of five Priority flora taxa have been recorded in the Mine Site Development Envelope (Mattiske 2016) and Ecologia (2012a, 2014b, 2015) (Table 55). Two Priority taxa were recorded by Mattiske (2016); *Triodia caelestialis* (P3) was recorded widely as a groundcover and *Pterocaulon intermedium* (P3) was recorded infrequently and not associated with any specific landform, soil type or vegetation community. Proposed impacts to these species based on the Development Envelope are 8% and 17% respectively based on records in the survey area of Ecologia (2012a, 2014b, 2015) and Mattiske (2016). Given the widespread distribution of both taxa within the survey area and the scarcity of surveys in the less-accessible parts of the Dampier Peninsula, there is a reasonable expectation that more of these taxa would be found outside the Mine Site Development Envelope beyond known records (Mattiske 2016).

Three other priority taxa have been recorded infrequently in the Mine Site Development Envelope (Ecologia 2012a, 2014b, 2015); *Fuirena incrassata* (P3), *Fuirena nudiflora* (P1), and *Tephrosia valleculata* (P3). None of these taxa were recorded during the Mattiske (2016) survey, and their recording is uncertain as no specialist taxonomic identification was undertaken by Ecologia (2012a, 2014b, 2015). It is considered highly unlikely that *Fuirena nudiflora* is present as the project is located far outside its known distribution. In addition, none of these taxa are proposed to be cleared (Table 55). One record of *Tephrosia valleculata* (P3) is located within the Development Envelope; however it is outside of proposed disturbance areas.

Table 55: Numbers of Priority Flora Recorded Within the Survey Areas

Species	CC	Plants Within Development Envelope	Plants Within Disturbance Area	Total Population (Ecologia and Mattiske)	Percentage Impact (%) Within Development Envelope**	Percentage Impact (%) Within Disturbance Areas
Pterocaulon intermedium	P3	16	5	94	17	5
Triodia caelestialis	P3	10,665	770	135,363	8	6
Tephrosia valleculata	P3	1	0	3	33	0
Fuirena incrassata	P3	0	0	1	0	0
*Fuirena nudiflora**	P1	0	0	1	0	0

*Notes: CC = Conservation Code. * Unlikely to be correct identification.*

*** Based on assumption all records within Development Envelope will be removed.*

Some Ecologia data lacked population information. Where no data was provided, a count of one was assumed. Impacts are only based on site specific surveys, not regional population numbers, so percentage impacts are far higher than a total population count.

Clearing is ‘Likely’ to result in minor, localised loss of two conservation significant flora species, both of which are P3 species. These species were found to be widely distributed within the survey area. The potential residual impact from clearing on conservation significant flora, after implementation of management measures, is assessed as ‘Medium’.

Impact	Consequence	Likelihood	Residual Impact
Clearing resulting in loss of conservation significant flora	Minor	Almost Certain	Medium

8.1.2.2 Dust Generated from Construction and Mining Activities Resulting in Reduced Vegetation Health and Condition

Accumulation of dust particulates on leaf surfaces can occur as a result of exposure to dust, resulting in a reduced ability for plants to photosynthesise and transpire, causing decline in health and eventual plant death if not alleviated.

Dust is likely to be generated during construction as a result of clearing for support infrastructure such as the Site Access Road, accommodation village and mining infrastructure. During the operational phase, dust will be generated from clearing of topsoil and vegetation ahead of the progressing mining excavation, driving of vehicles on roads and tracks, mining of overburden and ore, screening of ore within MUPS and rehabilitation activities such as spreading of overburden, topsoil and vegetation. There will be an average of 10 return road train trips (20 individual road train movements) in each 24 hour period along the unsealed Site Access Road during the operational phase of the project.

Impacts from dust generation are likely to be limited to within 50 m of the generation point, and there are no listed Threatened species or communities located within the Mine Site Development Envelope or the immediate surrounding area. Several Priority species are located within and adjacent to the Mine Site Development Envelope, however these species are well represented locally and regionally.

Incidental impacts to vegetation health and condition would be 'Likely' to occur. The potential residual impact of dust generation on vegetation health and condition, after implementation of management measures, is assessed as 'Low'.

Potential impact	Consequence	Likelihood	Residual Impact
Dust resulting in reduced vegetation health and condition	Incidental	Likely	Low

8.1.2.3 Increased Presence of Weeds Resulting in Reduced Native Vegetation Health and Condition

Vegetation condition in the Mine Site Development Envelope ranged from Excellent to Poor, with the majority assessed as being Excellent to Very Good, despite grazing within the Mt Jowlaenga pastoral lease. Weeds have the potential to outcompete and displace native vegetation if introduced or conditions are altered to favour their growth. Additionally, weeds can displace palatable feed for stock, reducing carrying capacity of pastoral areas.

Weeds may be spread and/or introduced by poor hygiene practices on vehicles and equipment, resulting in soil and weed vegetative material being transported around site and being present on equipment entering and exiting site. Additionally, favourable conditions for weed growth may be encouraged by watering and nutrient loading from land irrigation of treated wastewater. Weed species are known to occur within the Mine Site Development Envelope and surrounds (Ecologia 2012a, 2014b, 2015; Mattiske 2016).

Given the existing presence of weeds it is considered 'Unlikely' that project activities will result in an increased presence of weeds or any increased competition with native species given the proposed management measures. The potential residual impact of weeds on terrestrial flora, after implementation of management measures, is assessed as 'Low'.

Impact	Consequence	Likelihood	Residual Impact
Increased presence and health of weeds resulting in reduced native vegetation health and condition	Minor	Unlikely	Low

8.1.2.4 Modification of Surface Water Flows Resulting in Loss, or Reduced Health and Condition, of Native Vegetation

Small-scale, localised changes to surface water flows as a result of construction of infrastructure and the progressive excavation of the mineral deposit area are likely to occur during the wet season (December to April) following rainfall events. Changes in surface water flows may impact on established vegetation that is no longer receiving adequate resources to support growth, or vegetation may become inundated through extended ponding of stormwater, or failure of pipelines or other water infrastructure. Inundation causes stress and plant death when prolonged in those species not adapted to flooded conditions by decreasing oxygen levels within soils and impeding root respiration.

The volumes of runoff generated from the catchment upstream of infrastructure and the progressive mining excavation will be relatively small as they are adjacent to the major drainage divide between the Fraser River Catchment and Fraser River South Catchment, and therefore there is low flow accumulation. Additionally, runoff from the Mine Site area is inherently low due to low surface relief and high soil infiltration rates, with rainfall readily infiltrating through the soil to be utilised by vegetation in situ. This is evident by the absence of any defined drainage channels within the mine deposit area. In those areas outside of the mine deposit area where there are defined channels associated with runoff, such as across the proposed Site Access Road, infrastructure will be constructed with culverts and other drainage features to allow water to move through unimpeded.

It is considered 'Unlikely' that project activities will result in a decrease in health or abundance of native vegetation as a result of modifications to surface water flows. The potential residual impact of modifications to surface water flows on native vegetation, after implementation of management measures, is assessed as 'Low'.

Impact	Consequence	Likelihood	Residual Impact
Modification of surface water flows resulting in loss or reduced health and condition of native vegetation	Incidental	Unlikely	Low

8.1.2.5 Groundwater Abstraction Resulting in Loss, or Reduced Health or Condition, of Groundwater Dependent Ecosystems

Discussion on the impacts to potential GDEs is provided in Section 8.3.2.1.

8.1.2.6 Altered Fire Regime Resulting in Loss or Reduced Health and Condition of Native Vegetation

Bushfires are often caused by lightning and are considered a natural part of the environment as they can assist with regeneration of some species and ecosystems. Mining activities have the potential to ignite bushfires through hot work and other activities. Increased fire intensity and frequency can impact local flora and vegetation (Environs Kimberley 2013; EPA 2006b).

The presence of the project will reduce prescribed or intentional burning within the Mine Site Development Envelope and its surrounds, however mining activities will provide additional potential ignition sources. In order to reduce the likelihood of accidental ignition as a result of the project, fire and emergency management procedures will be developed for the project.

Vehicles will not be permitted to leave access tracks or cleared areas. Firefighting equipment will be maintained within light vehicles, earth moving equipment and buildings. Larger scale firefighting response will be provided as part of the projects Emergency Response Plan. Fire Breaks will be installed at key locations to minimise risk to people and infrastructure. Lightning protection will be installed within the processing plant to minimise risk of damage to key infrastructure. Implementation of a Hot Work permit system will minimise the risk of accidental fire due to project activities. The result of these changes is likely to be a reduction in widespread cool, controlled burns across the Mine Site Development Envelope and an increase risk of uncontrolled, hot burns for small areas within the Mine Site Development Envelope.

Fires may 'Possibly' cause 'Incidental' damage to native vegetation. The potential residual impact of increased fire risk on native vegetation, after implementation of management measures, is assessed as 'Low'.

Impact	Consequence	Likelihood	Residual Impact
Altered Fire regime resulting in loss or reduced health and condition of native vegetation	Incidental	Possible	Low

8.1.3 Management Measures

A summary of key measures to address potential impacts on flora and vegetation are listed in Table 56.

Table 56: Proposed Management Measures for Flora and Vegetation for the Mine Site Development Envelope

Potential Impact Requiring Management	Measure
Clearing resulting in loss of vegetation communities or significant species	• Land disturbance will be kept to the minimum necessary for development of the project. • Existing disturbed areas will be used wherever possible to minimise total ground disturbance. • Land clearing will be undertaking progressively with the amount of active disturbance minimised. • Ground disturbance procedures and a permitting system will be implemented. • Progressive rehabilitation will be undertaken on disturbed areas as they become available. • Monitoring of analogue and rehabilitated areas will be undertaken to ensure short, medium and long-term rehabilitation objectives are achieved. Monitoring will be carried out on a regular basis to assess the success of revegetation in rehabilitated areas. • Ongoing development of monitoring methodology and rehabilitation techniques will occur during the life of the project. Further assessments over time will plot the development of rehabilitated areas against analogue sites and progression towards completion targets. • Topsoil and vegetation (including woody debris) will be respread over rehabilitated areas to act as a seed source and to protect the soil from erosion. • Local provenance seed and propagated material will be used, if required, to rehabilitate disturbed areas • The site induction program will provide information on protection of vegetation and ground disturbance authorisation procedures.
Dust generated from mining activities resulting in reduced vegetation health and condition or loss of significant flora	• Vehicles and mining equipment will keep to designated roads. • Dust suppression will be carried out during construction, operation and closure.

Potential Impact Requiring Management	Measure
Increased presence and health of weeds resulting in reduced vegetation health and condition	• A weed hygiene system will be developed and implemented in consultation with the pastoralist. • Weed inspections will be conducted following significant rainfall, and depending on results, appropriate management actions will be implemented if required.
Modification of surface water flows resulting in loss or reduced health and condition of native vegetation	See Section 8.3.3 – Hydrological Processes Management Measures, Infrastructure causing localised reduction in surface water volumes and Infrastructure changing local drainage patterns and increasing flood risk.
Altered fire regime resulting in loss or reduced health and condition of native vegetation	• Firefighting equipment will be located on site and emergency personnel will be trained in fire response • Lightning protection equipment will be installed as part of project design where necessary. • Vehicles will not be permitted to leave access tracks or cleared areas. • A Hot Work Permit system will be developed and implemented. • All machinery and vehicles undertaking clearing activities will be fitted with firefighting equipment. • Sheffield will work with the pastoralist, Traditional Owners and DFES to undertake prescribed burns and install and maintain firebreaks if required so that potential environmental damage from extreme and out of control wildfires is minimised and infrastructure and the community are protected throughout the life of the project. • The project site induction will include information on the prevention and management of fires.
Radiation exposure resulting in loss or reduced health and condition of native vegetation	• Rehabilitated areas will be monitored to ensure radiation levels are within environmental screening criteria (10 µGy/h) or established pre-mining background levels.

8.1.4 Predicted Outcome

Clearing will result in the loss of vegetation however the majority of clearing (86%) is of communities that are common and widespread and all vegetation communities are represented outside the clearing footprint. Furthermore, the main clearing area is for the Mine Site Area, which will be progressively cleared and rehabilitated, therefore maintaining representation and diversity in the wider area as impacts will be short to medium term.

It is recognised that individuals of Priority listed species *Triodia caelestialis* (P3) and *Pterocaulon intermedium* (P3) will be impacted as a result of the proposal, however these taxa are considered to be widespread within the wider environment and are not restricted to the Mine Site Development Envelope. Whilst the Priority flora that Ecologia have recorded could not be substantiated by Mattiske (2016), impacts are not expected to be significant.

Dust, increased presence of weeds, modification of surface water flows, fire regimes and radiation exposure may affect flora and vegetation; however these impacts will result in localised and incidental effects on the health, abundance and structure of vegetation communities, all of which are well represented in the region.

Sheffield considers that the potential impacts to flora and vegetation will be able to be adequately managed such that the environmental objective for flora and vegetation (Section 8.1) will be met.

8.2 TERRESTRIAL FAUNA

The EPA's objective in relation to terrestrial fauna is "*to maintain representation, diversity, viability and ecological function at the species, population and assemblage level*".

8.2.1 Key Statutory Requirements, Environmental Policy and Guidance

Terrestrial fauna are protected under Commonwealth and State legislation, primarily governed by three Acts:

- *Wildlife Conservation Act 1950* (WA).
- *Environmental Protection Act 1986* (WA).
- *Environment Protection and Biodiversity Conservation Act 1999* (Cth).

In addition to Commonwealth and State legislation, the following policy and guidance statements were considered in undertaking fauna surveys and in the impact assessment for terrestrial fauna:

- EPA Position Statement No. 3, Terrestrial Biological Surveys as an Element of Biodiversity Protection (EPA 2002).
- EPA Guidance Statement No. 56, Terrestrial Fauna Surveys for Environmental Impact Assessment (EPA 2004d).
- EPA Guidance Statement No. 20, Short Range Endemic Invertebrate Fauna (EPA 2009a).
- EPA and DEC Technical Guide – Terrestrial Vertebrate Fauna Surveys for Environmental Impact Assessment (EPA and DEC 2010).
- Survey Guidelines for Australia's Threatened Mammals (DSEWPC 2011).
- Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) Guide G-1, Radiation Protection of the Environment (ARPANSA 2015).

8.2.2 Assessment of Potential Impact

Studies were carried out to provide baseline information to assist with assessing potential impacts to terrestrial fauna; these are detailed in Section 4.2.9. A description of the terrestrial vertebrate fauna found in the vicinity of the project is provided in Section 4.2.9, and a description of Short Range Endemic (SRE) species in Section 4.2.9.

Vertebrate fauna surveys recorded a total of 20 mammals, 118 birds, 44 reptiles and 8 amphibians occurring within the Mine Site Development Envelope or surrounding areas. Of these, nine were of conservation significance; however, only three were recorded within the Mine Site Development Envelope as shown in Figure 31 and Table 22. These were the Lakelands Downs Short-tailed Mouse, Greater Bilby and Rainbow Bee-eater.

Potential impact on the Greater Bilby (*Macrotis lagotis*), management measures and predicted outcomes are addressed in Section 13– Matters of National Environmental Significance.

SRE species surveys conducted in 2014 yielded a total of 200 invertebrate specimens with a total of 6 orders, 11 families and 31 taxa. Of these species, 22 were identified as being potential SRE, with one species (the land snail *Rhagada bulgana*) confirmed as a SRE (Section 4.2.9.5).

Potential impacts to terrestrial fauna in the Mine Site Development Envelope may occur as a result of:

- **Fragmentation of vertebrate fauna habitat resulting in displacement of fauna**.
- **Habitat clearing causing disturbance of conservation significant fauna species.**
- **Loss of SRE fauna habitat resulting in loss of SRE.**

- **Vehicle strike causing injury or death of native fauna.**
- **Increase in pest species impacting native fauna** – potential increase in populations and number of species of pests due to establishment of domestic waste disposal and permanent water storage facilities.
- **Altered fire regime impacting native fauna** – fire regimes may be altered due to implementation of the project.
- **Light and noise pollution disrupting native fauna.**
- **Fauna entrapment leading to injury or death**.

Other potential impacts were screened out from further assessment (Section 7.4) as they were either assessed as not likely to occur or were unlikely to have any discernible consequence on any factor different to background levels:

Stressor	Justification for Exclusion
Radiation exposure to native fauna	The vast majority of (98%) of process waste streams is from ilmenite processing or initially rejected sand/slimes material with low activity (0.39 Bq/g Appendix 21). Material with activity less than 1 Bq/g based on composition of Sheffield waste materials was not found to trigger Tier 1 Environmental screening criteria of 10 µGy/h using ERICA software assessment (ARPANSA 2015) for terrestrial fauna. Sheffield commit to mixing and co-disposal of wastes to <1 Bq/g (combined activity c.a. 0.74 Bq/g). Backfill areas will be monitored to ensure radiation levels are within environmental screening criteria (10 µGy/h) or established pre-mining background levels. The inherent use of wet slurries for transport of mine waste back to the void minimises potential for dust emissions of higher activity material.

Additionally the following species were screened out from further assessment as they were assessed as not likely to be either directly or indirectly impacted by the project (Section 4.2.9.3):

- Gouldian Finch.
- Oriental Pratincole
- Dampierland Plain Slider.
- Dampierland Burrowing Snake.
- Dampierland Peninsula Goanna.
- Wood Sandpiper.
- Eastern Yellow Wagtail.
- Grey Wagtail.

The assessed likelihood, consequence and residual impact (as per Section 7.3), is provided below for each potential impact.

8.2.2.1 Fragmentation of Vertebrate Fauna Habitat Resulting in the Displacement of Fauna

Clearing of vegetation can lead to fragmentation of fauna habitat and increased resource competition with species already using adjacent uncleared habitat. The proposed percentage impact from construction of the project to fauna habitats compared to known distributions by Ecologia mapping is shown in Table 57. The conceptual site layout over habitat type is shown in Figure 30.

Table 57: Proposed Impacts to Fauna Habitats of the Mine Site Development Envelope and Surrounding Area

Habitat	Vegetation Description	Geology, Soil, Landform Description	Total Mapped Area (ha)	Proposed Disturbance Within Survey Area (ha)
Pindan Shrubland	*Corymbia greeniana*, over a moderately open to dense shrub layer consisting primarily of *Acacia tumida var tumida*, *Acacia platycarpa* and *Grevillea refracta*. Ground vegetation layers consists of a mix of grasses including *Triodia caelestialis*, *Aristida holathera var holathera*, *Crysopogon* sp., *Eriachne obtusa* and *Sorghum plumosum*	Flat plains, with weak orange to red sandy-loam soils	9,908.1	2,036
Sandstone Range and Footslopes	*Corymbia dendromerinx* over moderately dense *Acacia drepanocarpa* subsp. latifolia over a ground vegetation layer of dense *Triodia caelestialis* hummock grassland and *Sorghum plumosum* tussock grassland.	Undulating hills, slopes and gullies of orange sandy soils with Sandstone residuals ranging from moderately dense pebbles to dense rocks	3,835.5	102.2
Savannah Woodland	Scattered *Eucalyptus tectifica* and *Brachychiton diversifolius*, with open to moderately dense shrubs of mainly *Acacia platycarpa*	Firm brown-white sandy clay soils	1,950.3	134.4
		Total	**15,693.9**	**2,272.6**

A total of 2,036 ha of Pindan Shrubland, 102.2 ha of Sandstone Range and Footslopes, and 134.4 ha of Savannah Woodland will be impacted over time by the project (Table 57). However, due to the nature of mineral sands mining, rehabilitation will be progressive as areas become available after mining, creating additional new habitat which can be colonised throughout the project life. Clearing activities will also be managed to ensure clearing is strictly limited to that necessary for the operations.

Clearing is 'Likely' to result in some displacement of fauna, however the overall habitat in the area will remain intact and is not anticipated to have lasting effects on population viability or abundance. The potential residual impact from the fragmentation of habitat on vertebrate fauna, after implementation of management measures, is assessed as 'Low'.

Impact	Consequence	Likelihood	Residual Impact
Fragmentation of vertebrate fauna habitat resulting in displacement of fauna	Incidental	Likely	Low

8.2.2.2 Habitat Clearing Causing Disturbance of Conservation Significant Fauna Species

The Lakelands Downs Short-tailed Mouse occupies a diverse range of habitats across northern Australia, from Cape York to the Pilbara in WA, with populations also occurring on Thevenard and Serrurier Island. Home ranges average around 5.3 ha and are larger during the non-breeding season. Habitat preferences are sandy soils and cracking clays within WA (DPaW 2016d), which corresponds to the Pindan Shrubland and Savannah Woodland habitat types in the surveyed areas. The single specimen collected was found on the border of these two habitat types.

Based on project design, 2,036 ha (21%) of the Pindan Shrubland and 134.4 ha (7%) of the Savannah Woodland habitats within the survey area will be impacted by the project. This leaves 9,688 ha (82%) of potential habitat available for colonisation, and affected individuals are expected to move to suitable habitats outside the impact area.

Clearing associated with the project represents a localised loss of habitat for the conservation significant Short-tailed Mouse and minimal fragmentation of its habitat. Surveys have recorded that suitable habitat (Spinifex and tussock grasslands on cracking clays and acacia shrubland, samphire, woodlands and stony ranges) occur throughout most of the studied areas (Ecologia 2014a).

The Rainbow Bee-eater is found throughout mainland Australia except in desert areas and breeds throughout most of this range, although southern birds move north to over winter. Its habitat preference is most often open forest, woodlands, shrublands and cleared areas, usually near water. As detailed above 9,688 ha (82%) of mapped Pindan Shrubland and Savannah Woodland habitat will not be impacted by the project and sufficient habitat remains for the protection of this species in the area.

Forked-tailed Swifts are nomadic in response to broad scale weather pattern changes and are attracted to thunderstorms. They rarely land, living almost exclusively in the air. The species is considered a transient visitor to the Mine Site Development Envelope and may at times be found in varying numbers foraging in the air above the project area however this species does not rely on the area for its survival and will move to suitable habitats within the region.

Significant trees (especially those with hollows) for bird, bat and reptile habitat will be retained where practicable.

Project clearing will 'Almost Certainly' cause a localised, medium term loss of habitat for the conservation significant Short-tailed Mouse and Rainbow Bee-eater, however the habitats of both species are well represented in the region. The residual impact of habitat clearing on the Short-tailed Mouse and the Rainbow Bee-eater, after implementation of management measures, is assessed as 'Medium'.

Impact	Consequence	Likelihood	Residual Impact
Habitat clearing causing disturbance of conservation significant fauna species	Minor	Almost Certain	Medium

8.2.2.3 Loss of SRE Fauna Habitat and Loss of SRE

Potential impacts that could affect SRE fauna as a result of the project include:

- Clearing of vegetation or habitats with known potential to support SRE fauna.
- Directly removing known populations of SRE fauna.

The status of SRE invertebrate fauna recorded at Mine Site Development Envelope and surrounding area was based on categories developed by the Western Australian Museum and modified by Ecologia (2014a) in order to describe the status of taxa using current knowledge of distribution and biology of each species.

A vulnerability rating has been included in Table 58 in order to inform the assessment of the likelihood of SRE species being lost as a result of clearing in the Mine Site Development Envelope. This vulnerability rating is based on the number of locations where specimens were collected and the prevalence outside the Mine Site Development Envelope of the habitat types at these locations. Species collected from multiple locations within a common habitat type are considered to have a low vulnerability rating, whilst those collected from either multiple locations or a common habitat type (but not both) are considered to have a medium vulnerability rating. Species which were collected in only one location in a rare habitat type are considered to have a high vulnerability rating.

Most SRE species recorded in the Mine Site Development Envelope are considered to have a low vulnerability rating, and no SRE species are considered to have a high vulnerability rating (Table 58). Of the six species with a medium vulnerability rating, five (*Aname* 'MYG387?', *Aname* ‘sp. indet.’, *Aname* ‘sp. juv.’, *Urodacus sp.* indet. and *Olpiidae* ‘genus indet. (juvenile)’) were either juvenile or female and thus identification to species level could not be confirmed.

Lychas ‘JPP2’ (a morphospecies of *Lychas* ‘JPP’) has a medium vulnerability rating due to only being collected once, and as such will be impacted by clearing in the Mine Site Development Envelope. However based on species surrogates (*Lychas* ‘JPP’, *Lychas* ‘JPP1’ and *Lychas* ‘JPP3’, which are found several kilometres from *Lychas* ‘JPP2’) it can be inferred that *Lychas* ‘JPP2’ has a high probability of occurring outside the Mine Site Development Envelope. In addition and taking into consideration habitat surrogates, *Lychas* ‘JPP2’ was recorded from the extensive Pindan Shrubland and Savannah Woodland habitats which extend well beyond the impact area, increasing the probability of the species occurring outside the Mine Site Development Envelope.

In order to protect SRE habitat clearing activities will be managed to ensure clearing is strictly limited to that necessary for operations and disturbed areas will be rehabilitated as they become available.

It is ‘Almost Certain’ that the project will result in localised loss of SRE habitat (Figure 32), however the habitat types that most species were found in are well represented in the region. It is ‘Almost Certain’ that the project will cause a loss of SRE individuals, although it is not expected that this will affect population viability or abundance. The potential residual impact from loss of SRE habitat on SRE, after implementation of management measures, is assessed as ‘Medium’.

Impact	Consequence	Likelihood	Residual Impact
Loss of SRE fauna habitat and loss of SRE	Incidental	Almost Certain	Medium

Table 58: Relative Vulnerability of the Mine Site Development Envelope on SREs

Order	Family	Species	SRE Status	Collected From Multiple Locations	Collected From Common Habitat	Relative Vulnerability
Mygalomorphae (Spiders)	Nemesiidae	*Aname* 'MYG284'	Potential	X	X	Low
		Aname 'MYG285'	Potential	X	X	Low
		Aname 'MYG387'	Potential	X	X	Low
		Aname 'MYG387?'	Note 1		X	Medium
		Aname 'MYG388'	Potential	X	X	Low
		Aname 'sp. indet.'	Note 2 and 3		X	Medium
		Aname 'sp. juv.'	Note 2 and 3		X	Medium
Arachnida (Opiliones)	Assamiidae	*Dampetrus* sp.	Potential	X	X	Low
Scorpiones (Scorpions)	Buthidae	Lychas 'annulatus'	No	X	X	Low
		Lychas 'broome'	Potential	X	X	Low
		Lychas 'JPP'	Potential	X	X	Low
		Lychas 'JPP1'	Potential	X	X	Low
		Lychas 'JPP2'	Potential		X	Medium
		Lychas 'JPP3'	Potential	X	X	Low
		Lychas 'multipunctatus'	No	X	X	Low
	Urodacidae	*Urodacus 'kraepelini'*	Potential	X	X	Low
		Urodacus sp. indet.	Note 2		X	Medium
Pseudoscorpiones	Sternophoridae	*Afrosternophorus* sp. indet.	No	X	X	Low
	Chernetidae	*Haplochernes* sp. Indet.	No	X	X	Low
	Olpiidae	*Beierolpium* 'sp. 8/4'	No	X	X	Low
		Olpiidae 'genus indet. (juvenile)'	Note 2 and 3		X	Medium
		Indolpium'sp. Indet.'	No	X	X	Low
Isopoda (Slaters)	Armadillidae	*Armadillidae* 'EE1501C'	Potential	X	X	Low
		Buddelundiinae 'genus indet. NE Broome'	Potential	X	X	Low
		Buddelundiinae sp. 74	Potential	X	X	Low
		Buddelundia sp. '90'	Potential	X	X	Low
		Buddelundia sp. '91'	Potential	X	X	Low

Order	Family	Species	SRE Status	Collected From Multiple Locations	Collected From Common Habitat	Relative Vulnerability
Gastropoda (Snails)	Subulinidae	*Eremopeas interioris*	No	X	X	Low
	Pupillidae	*Pupoides pacificus*	No	X	X	Low
	Camaenidae	*Quistrachia leptogramma*	Potential	X	X	Low
		Rhagada bulgana	Confirmed	X	X	Low

Note 1: Single female specimen captured. Could be conspecific with Aname 'MYG387'.

Note 2: Specimen was unable to be identified to species level.

Note 3: Only juveniles collected.

8.2.2.4 *Vehicle Strike Causing Injury or Death of Native Fauna*

Injury or death of fauna from vehicle strike is most likely to occur along the Site Access Road and village access roads due to relatively high volumes of traffic. The implementation of lower traveling speeds (particularly at night) will reduce this likelihood of vehicle strikes. Additionally, the width of the Site Access Road corridor (up to 62 m including other services) will allow drivers to identify fauna well in advance allowing them to slow down or stop. All fauna injuries and/or deaths will be reported as required and the site induction program will provide information of fauna of conservation significance, their appearance and habitats.

It is ‘Likely’ that infrequent vehicle strikes will occur within the Mine Site Development Envelope, but this will not affect fauna population viability or species diversity. The potential residual impact from vehicle strikes on native fauna, after implementation of management measures, is assessed as ‘Low”.

Impact	Consequence	Likelihood	Residual Impact
Vehicle strike causing injury or death of native fauna	Incidental	Likely	Low

8.2.2.5 *Increase in Pest Species Impacting Native Fauna*

The establishment of both domestic waste disposal areas and new water sources can result in an increase in pest species attracted to the area. This can result not only in an increase in predation of native fauna but also result in an increase in competition for food resources. Fencing of waste disposal and water sources will limit the increase of these species within the Mine Site Development Envelope. Additional management measures such as the regular covering of wastes as well as trapping of feral predators will further reduce the impact to native fauna.

It is ‘Unlikely’ that pest species will impact upon the population viability and abundance of native fauna populations. Any increase in pest species numbers will be localised, and it is anticipated that controls will be effective and will limit pest species populations from becoming established. The potential impact of an increase in pest species on native fauna, after implementation of management measures, is assessed as ‘Low’.

Impact	Consequence	Likelihood	Residual Impact
Increase in pest species impacting native fauna	Incidental	Unlikely	Low

8.2.2.6 *Altered Fire Regimes Impacting Native Fauna*

The Kimberley region is subject to frequent burning, which has increased in intensity in recent years; either as a result of natural or deliberate events (Section 4.2.11). Controlled burning conducted as part of pastoral activities will not be conducted on the same frequency or extent within the Mine Site Development Envelope as a result of implementation of the project. Due to the increased presence of people and machinery in the area there is however an increased risk of accidental fires, which could affect fauna and habitat on a local and regional scale. The project site induction will include information on the prevention and management of accidental fires. Should a fire occur, fauna are likely to move away from the fire.

Vehicles will not be permitted to leave access tracks or cleared areas. Firefighting equipment will be maintained within light vehicles, earth moving equipment and buildings. Larger scale firefighting response will be provided as part of the projects Emergency Response Plan. Fire breaks will be installed at key locations to minimise risk to people and infrastructure. Lightning protection will be installed within the processing plant to minimise risk of damage to key infrastructure. Implementation of a Hot Work permit system will minimise the risk of accidental fire due to project activities. The result of these changes is likely to be a reduction in widespread cool, controlled burns across the Mine Site Development Envelope and an increase risk of uncontrolled, hot burns for small areas within the Mine Site Development Envelope.

It is 'Unlikely' that an accidental fire will occur, and any loss of habitat from fire is likely to be localised and short-term. The potential residual impact of altered fire regime on native fauna, after implementation of management measures, is assessed as 'Low'.

Impact	Consequence	Likelihood	Residual Impact
Altered fire regime impacting native fauna	Incidental	Unlikely	Low

8.2.2.7 *Light and Noise Pollution Disrupting Native Fauna*

Light and noise pollution can result in a disruption to the natural behaviours of fauna, in particular those that are nocturnal by interfering with the timing of necessary biological activities. Artificial light sources and noise pollution at night seriously constrain their lives, exposing them to predators and reducing the time available to find food, shelter, or mates with which to reproduce.

The amount of natural habitat surrounding the project means that impacts are likely to be minimal, and susceptible affected fauna are likely to move away from noise or light sources. Management measures to limit the impact of noise and light on fauna will be considered during the design, construction and operational phases of the project and engineering controls implemented where possible.

Light and noise may 'Rarely' impact local fauna, causing some displacement of fauna with no lasting effects; however no mortality of individuals is expected. The potential residual impact of light and noise on fauna, after implementation of management measures, is assessed as 'Low'.

Impact	Consequence	Likelihood	Residual Impact
Light and noise pollution disrupting native fauna	Incidental	Rare	Low

8.2.2.8 *Fauna Entrapment Leading to Injury or Death*

Trenches, excavations, and water storage structures often have steep, slippery sides which prevent fauna that fall into them from escaping. Fauna may also be attracted to waste storage bins or domestic waste facilities, and become trapped. Entrapment may lead to fauna injury or death from starvation, dehydration, drowning, or injury. Artificial water sources will have fauna egress points so that fauna will be able to escape over and above being fenced. Open holes, trenches (if applicable) and the refuse impoundment will be fenced and visual inspections will be implemented to reduce the potential impact to fauna

Fauna mortalities are considered 'Unlikely' to occur, and will not result in effects on population viability or species diversity. The potential residual impact of entrapment on fauna, after implementation of management measures, is assessed as 'Low'.

Impact	Consequence	Likelihood	Residual Impact
Fauna entrapment leading to injury or death	Incidental	Rare	Low

8.2.3 Management Measures

A summary of key measures to address potential impacts on terrestrial fauna is shown in Table 59.

Table 59: Proposed General Management Measures for Terrestrial Fauna for the Mine Site Development Envelope

Potential Impact Requiring Management	Measure
Fragmentation of vertebrate fauna habitat resulting in displacement of fauna	• Clearing activities will be managed to ensure clearing is strictly limited to that necessary for operations. • Land clearing will be undertaking progressively with the amount of active disturbance minimised. • Disturbed areas will be rehabilitated as they become available. • Topsoil and vegetation will be respread over rehabilitated areas to act as a seed source and mulch to protect the soil from erosion and provide habitat for fauna.
Loss of SRE fauna habitat resulting in loss of SRE	
Habitat clearing causing disturbance of conservation significant fauna species	• Significant trees (especially those with hollows) will be retained where practicable.
Vehicle strikes causing injury or death of native fauna	• Speed limits will be implemented for operational areas and the Site Access Road in order to minimise the risk of fauna injury or mortality from vehicle strike. • Personnel will be required to adhere to speed limits and drive to road/weather conditions to minimise risks of fauna injuries or death due to vehicle traffic • The Site Access Road will be constructed with a 5 m buffer of cleared area on each side with topsoil stockpiles located up to 20 m away from the trafficable surface. • Travel between dusk and dawn on the Site Access Road and village access road will be limited to essential travel with driving speed limits set to reduce the potential for road strikes. • The site induction program will provide information on fauna of conservation significance, including their appearance and habitats.
Increase in pest species impacting native fauna	• Sheffield will undertake pest animal control in co-operation with regional control programs. • Domestic waste facilities will be fenced and putrescible wastes will be regularly covered. • Borrow pits will be designed and constructed to minimise surface water ponding after rehabilitation.
Changes to fire regimes impacting native fauna	• Firefighting equipment will be located on site and emergency personnel will be trained in fire response. • Lightning protection equipment will be installed as part of project design where necessary. • Vehicles will not be permitted to leave access tracks or cleared areas. • A Hot Work Permit system will be developed and implemented. • All machinery and vehicles undertaking clearing activities will be fitted with firefighting equipment. • Sheffield will work with the pastoralist, Traditional Owners and DFES to undertake prescribed burns and install and maintain firebreaks if required so that potential environmental damage from extreme and out of control wildfires is minimised and infrastructure and the community are protected throughout the life of the project. • The project site induction will include information on the prevention and management of fires.

Potential Impact Requiring Management	Measure
Light and noise emissions disrupting native fauna	• Lights will be strategically placed and designed to shine towards plant operations and minimise light spill to the environment. • Equipment design will be specified to be within Australian standard noise limits.
Fauna entrapment leading to injury or death	• Artificial water sources will have egress points installed. • Open holes, trenches, the refuse impoundment, and any water holding facilities will be inspected regularly for fauna. • Domestic waste facilities will be fenced and putrescible wastes will be regularly covered.

8.2.4 Predicted Outcome

It is likely that clearing associated with the project will result in some habitat fragmentation, but the impacts on terrestrial vertebrate fauna (including conservation significant species) and SREs are likely to be incidental due to availability of habitat outside the Mine Site Development Envelope and the progressive nature of the majority of land clearing.

The presence of pest species, light, noise, and radiation may affect fauna, however these impacts are not considered likely to cause fauna injury or mortality. Fauna injury or mortality due to vehicle strikes, fire, or entrapment may occur, however are not considered likely to impact native fauna population viability or diversity. These impacts are able to be adequately managed by mitigation and management measures.

Sheffield considers that the potential impacts to terrestrial fauna will be able to be adequately managed such that the environmental objective for terrestrial fauna (Section 8.2) will be met, and that the residual impacts are therefore acceptable.

8.3 HYDROLOGICAL PROCESSES

The EPA's objective in relation to hydrological processes is "*to maintain the hydrological regimes of groundwater and surface water so that existing and potential uses, including ecosystem maintenance, are protected*".

8.3.1 Key Statutory Requirements, Environmental Policy and Guidance

Groundwater and surface water is protected by the following State legislation:

- *Rights in Water and Irrigation Act 1914 (WA).*
- *Country Areas Water Supply Act 1947 (WA).*
- *Environmental Protection Act 1986 (WA).*

In addition to State legislation, the following policy and guidance statements were considered in the impact assessment for hydrological processes:

- EPA Position Statement No. 4, Environmental Protection of Wetlands (EPA 2004a).
- Australian and New Zealand Guidelines for Fresh and Marine Water Quality 2000 (Commonwealth) (ANZECC and ARMCANZ 2000).
- State Water Quality Management Strategy Document No. 6 (DoW 2004).

- Operational Policy No. 5.12, Hydrogeological Reporting Associated with a Groundwater Well Licence (DoW 2009).
- Water Quality Protection Guidelines No. 11, Mining and Mineral Processing, Mine Dewatering (WRC 2000).
- DoW Report No. 12, Western Australian Water in Mining Guideline. Water licensing delivery report series (DoW 2013).
- Water Quality Protection Guidelines for Mining and Mineral Processing (WRC 2000).
- State Water Quality Management Strategy Document No. 6 (DoW 2004).
- National Water Quality Management Strategy (ARMCANZ and ANZECC 1995).
- Kimberley Regional Water Plan (DoW 2010).

The following documents were also considered:

- Kimberley Regional Planning and Infrastructure Framework (DoP and WAPC 2015).

8.3.2 Assessment of Potential Impact

8.3.2.1 Groundwater

Mine and mineral separation activities require water to be supplied at certain volumes during the project's life; Table 9 and Table 10 summarise the anticipated sources and extent of project water supply. During the early years of project life, overall water demand for the project is met entirely from a project-specific borefield targeting the Broome Sandstone Aquifer. In order to maintain safe mining conditions during later mining years, water is required to be abstracted from the mine deposit area, also within the Broome Sandstone Aquifer. The dewatering volume will exceed project demand, so it is proposed to artificially recharge the excess back into the Broome Sandstone Aquifer downstream of the mining operations. There is no other suitable management alternative (e.g. use or disposal).

Groundwater within the Broome Sandstone Aquifer underlying the Mine Site Development Envelope is deep (in excess of 20m below ground level). Several areas of perched groundwater exist within the Mine Site Development Envelope (Section 4.2.5.5); these are not connected with the deeper Broome Sandstone Aquifer to be targeted by abstraction and will not be affected by dewatering (Rockwater 2016; Appendix 8).

A three-dimensional groundwater model was prepared to enable predictions of the extent and magnitude of groundwater drawdown and mounding associated with life of mine water demand (Rockwater 2016; Appendix 8). The model was calibrated against a number of data sets and is considered appropriate for prediction of cumulative impacts associated with the borefield and with tailings storage of mine waste backfill. The model was prepared to enable a range of climate change scenarios to be considered, with variations to outcomes identified.

Modelling has indicated that abstraction within the water supply and dewatering borefields will cause drawdown of existing groundwater levels (Table 60). A 1 m drawdown contour is shown in Figure 44 for Year 15; Figure 45 for Year 32; and Figure 46 for Year 47 in mine life for a variety of climate scenarios (annual rainfall 10, 50 and 90 percentile from predicted). Modelled differences between the three climate scenarios are small, as would be expected given that most of the dewatering comes from aquifer storage rather than recharge. Drawdown extent is maximal under the high rainfall scenario which requires extra dewatering effort, and conversely under the dry rainfall scenario, less dewatering effort is required. A gradual increase in the area impacted by the 1 m drawdown contour occurs during the period of dewatering, from Year 15 to Year 47. Post-mining aquifer recovery was simulated via the transient response of aquifer recovery from Year 47 onwards, and did not include borefield extraction or reinjection. At two years post-mining, the magnitude of drawdown has declined markedly from greater than 40 m to less than 7.5 m. After 10 years post-mining the residual drawdown is confined to an area close to the mining deposit area and the magnitude is less than 2 m (Figure 47).

Groundwater mounding of up to about 12 m is predicted as a result of reinjection at the end of mine life (Table 60). However, as the unsaturated zone is more than 30 m deep in this region, groundwater mounding is not predicted to result in surface-waterlogging or other mounding impacts (Rockwater 2016). Mounding due to seepage from tailings disposal is likely to occur (especially in the first 15 years of mining) with modelling suggesting that it may be up to about 24 m (Table 60). However, as for reinjection, tailings mounding occurs in regions where the unsaturated zone is relatively deep (about 40 m), therefore it is not predicted to result in surface-waterlogging or other mounding impacts (Rockwater 2016). Post-mining aquifer recovery was simulated via the transient response of aquifer recovery from Year 47 onwards, and did not include borefield extraction or reinjection. Mounding rapidly reduces upon cessation of mining, with mounding negligible after two years. Predicted mounding contours at 10 years post-mining (Figure 47) show that residual groundwater mounding is negligible.

Table 60: Summary of Modelled Drawdown and Mounding from Project Activities

Assessment Area	Mining Year		
	Year 15	Year 32	Year 47
Borefield Drawdown	≤ 11 m	≤ 20 m	≤ 43 m
Reinjection Borefield Mounding	N/A	N/A	≤ 12 m
Tailings Seepage Mounding	≤ 20 m	≤ 11 m	≤ 3 m

Impacts to groundwater quality are discussed in Section 8.4.

Potential impact pathways for groundwater regimes are:

- **Groundwater abstraction and dewatering causing localised lowering of groundwater levels** causing vegetation decline in groundwater dependent ecosystems.

Other potential impacts to groundwater were screened out from further assessment (Section 7.4) as they were either assessed as not likely to occur or were unlikely to have any discernible consequence on any factor different to background levels:

Stressor	Justification for Exclusion
Abstraction causing a reduction in groundwater availability to other users	Groundwater availability in the Canning-Pender Groundwater sub-area is currently estimated to be 47.7 GL/yr (DoW, 2010), significantly more than the proposed project-related net abstraction of approximately 10.7 GL/yr or 12.2 GL/yr in the first year (net abstraction is the water supply and dewatering volume minus aquifer reinjection of excess dewatering volumes). Additionally, the groundwater resources of the Broome Sandstone Aquifer for the Canning-Pender sub-area of the Canning-Kimberley Groundwater Area have 95.4% of its 50 GL/yr available allocation unused. Licence entitlements within the sub-area total 2.3 GL/yr, with one major user (Kilto Station, 2 GL/yr) located about 40 km southwest of the Mine Site Development Envelope. The nearest licensed users and nearest registered Indigenous heritage sites are at least 30 km from the Mine Site Development Envelope, outside the modelled drawdown. It is not thought that drawdown will impact on the Water Corporation's Broome Borefield located in the Broome Groundwater Area about 12 km northeast of Broome (about 80 km southwest of the Mine Site Development Envelope) (Figure 24).

Stressor	Justification for Exclusion
Localised lowering of groundwater levels reducing subterranean fauna habitat	Given the wide extent of the Broome Sandstone Aquifer across the Canning Basin, together with the lack of any significant obligate stygofauna identified within the study area and the relatively localised impact on aquifer saturated thickness, groundwater drawdown will have incidental impacts on subterranean fauna (See Section 10.2.2). No specific management actions are proposed for subterranean fauna.
Process waste disposal and water reinjection causing localised increase in groundwater levels	Groundwater mounding of up to about 13 m is predicted as a result of reinjection at the end of mine life. However, as the unsaturated zone is more than 30 m deep in this region, groundwater mounding is not predicted to result in surface-waterlogging or other mounding impacts (Rockwater 2016). Mounding due to seepage from tailings disposal is likely to occur (especially in the first 15 years of mining) with modelling suggesting that mounding may be up to about 24 m. However, as for reinjection, tailings mounding occurs in regions where the unsaturated zone is relatively deep (about 40 m), therefore groundwater mounding is not predicted to result in surface-waterlogging or other mounding impacts (Rockwater 2016).

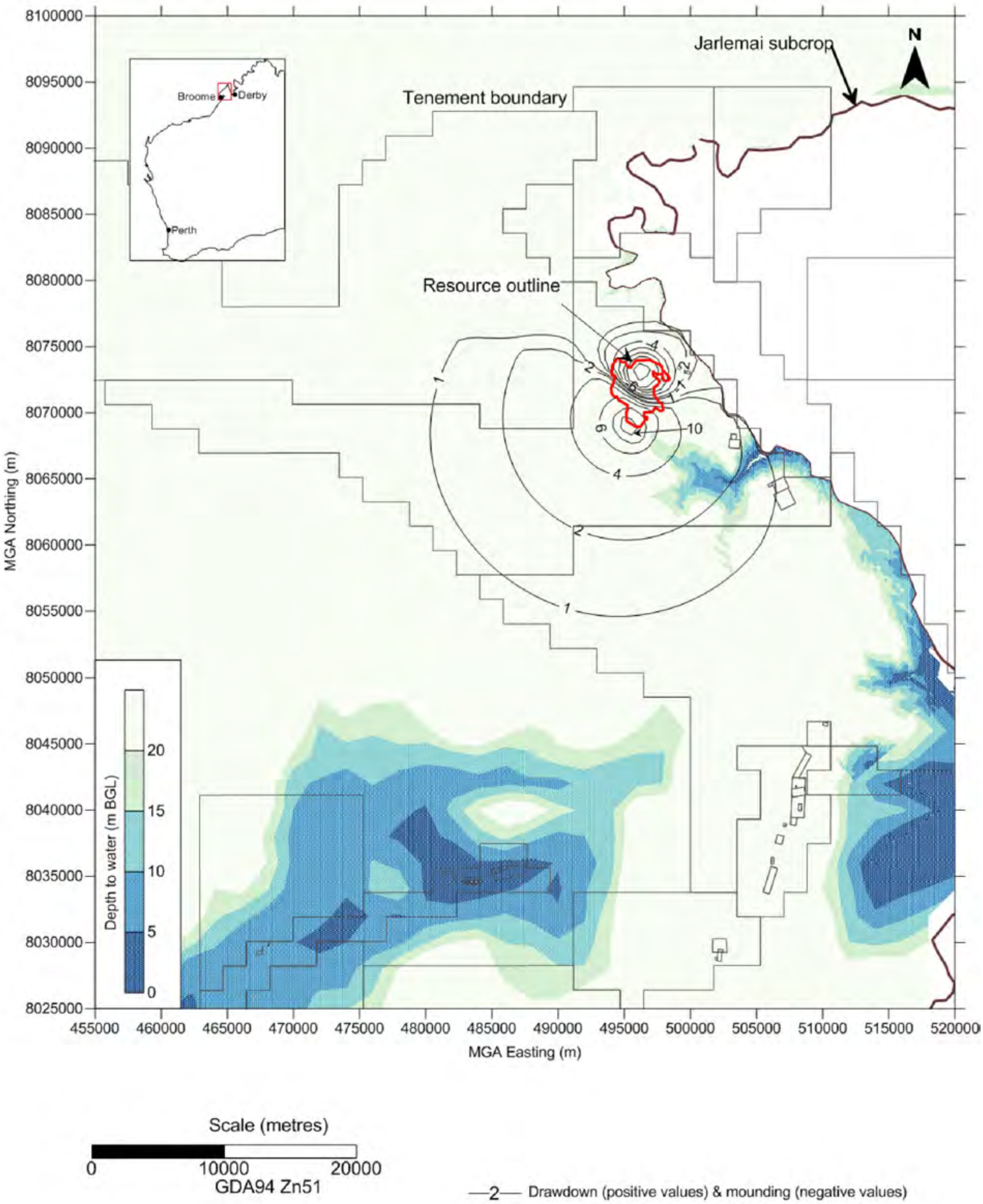


Figure 44: Modelled Groundwater Drawdown and Mounding Year 15 of Mine Life

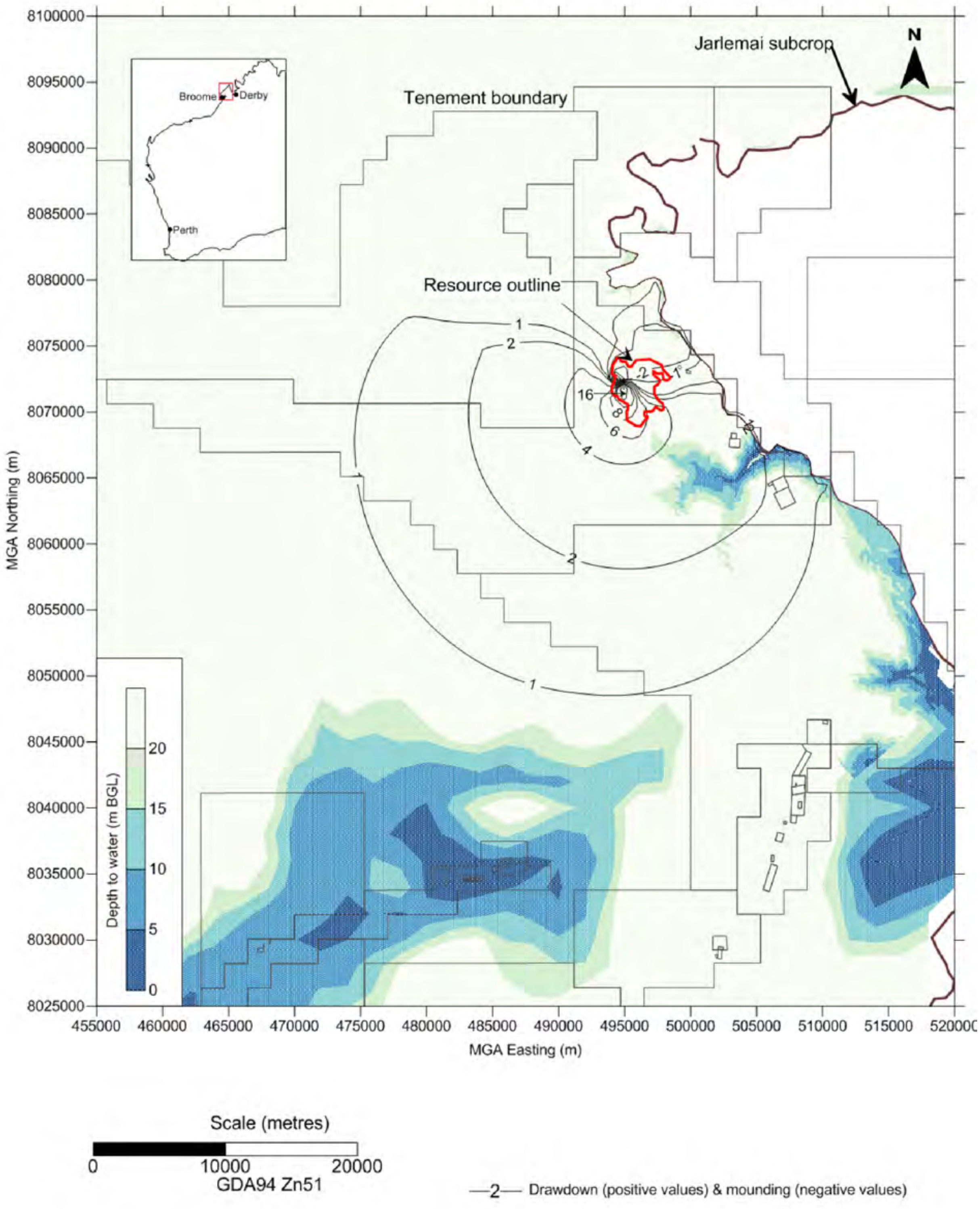


Figure 45: Modelled Groundwater Drawdown and Mounding Year 32 of Mine Life

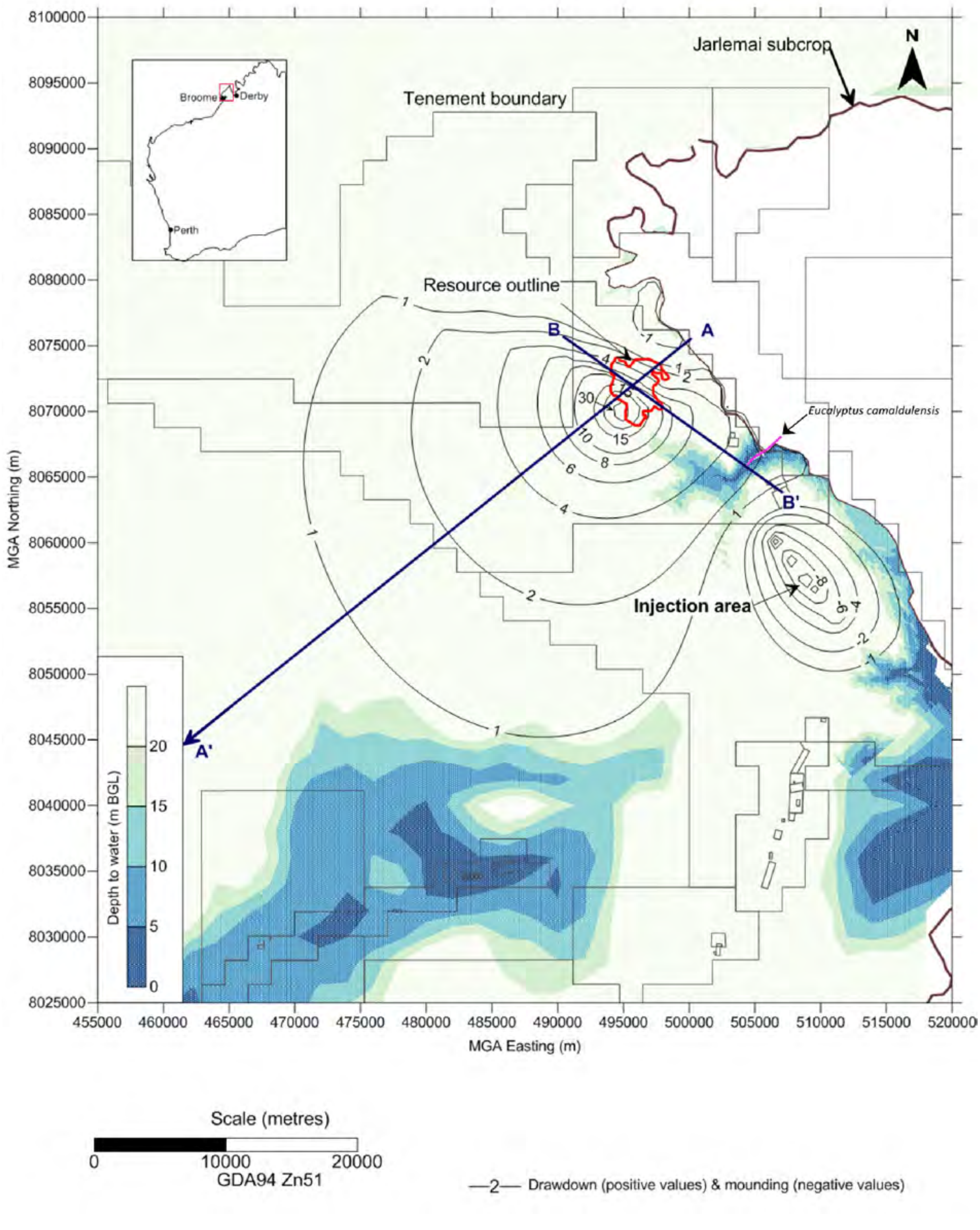


Figure 46: Modelled Groundwater Drawdown and Mounding Year 47 of Mine Life

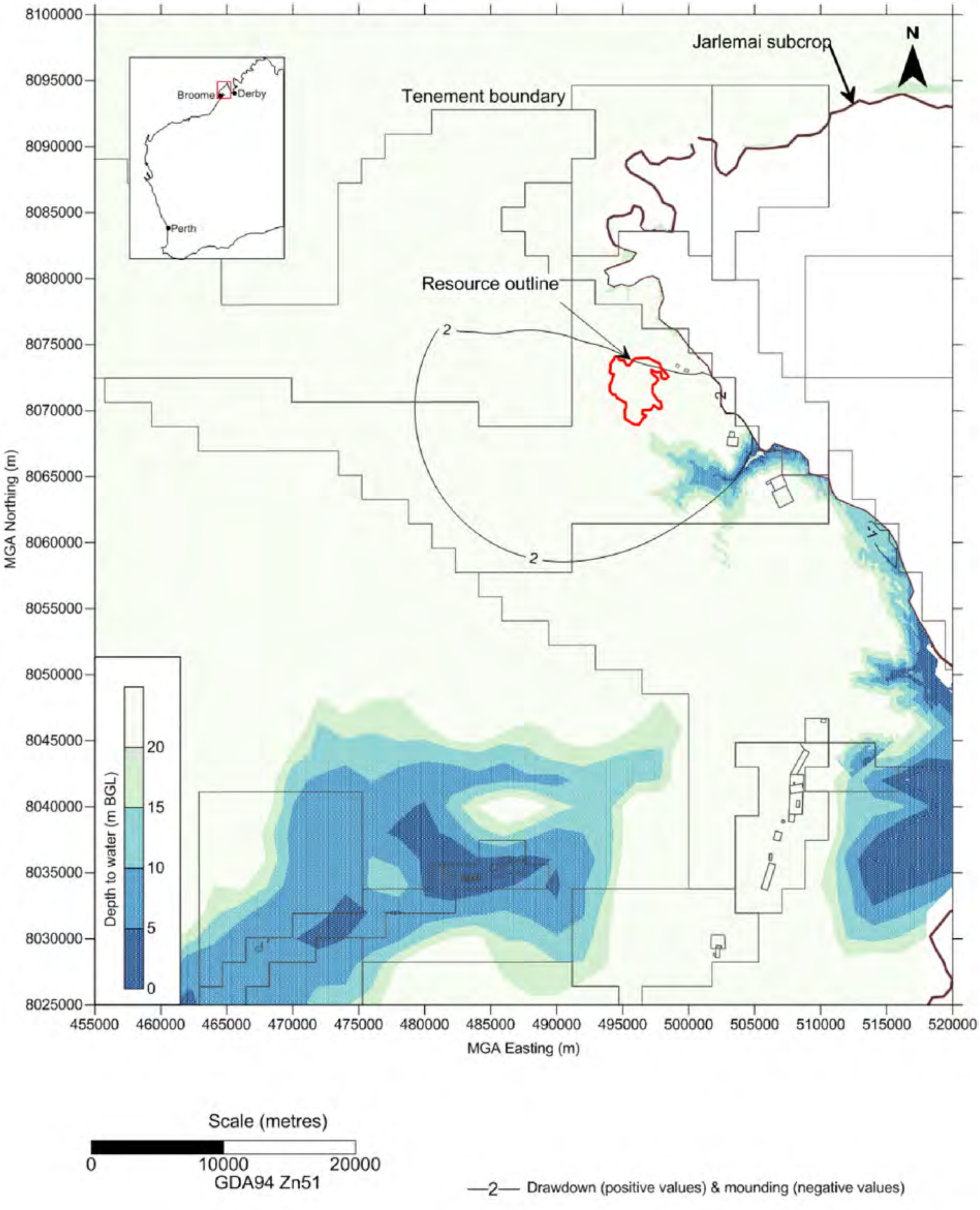


Figure 47: Modelled Groundwater Drawdown and Mounding 10 Years Post Cessation of Groundwater Abstraction and Reinjection

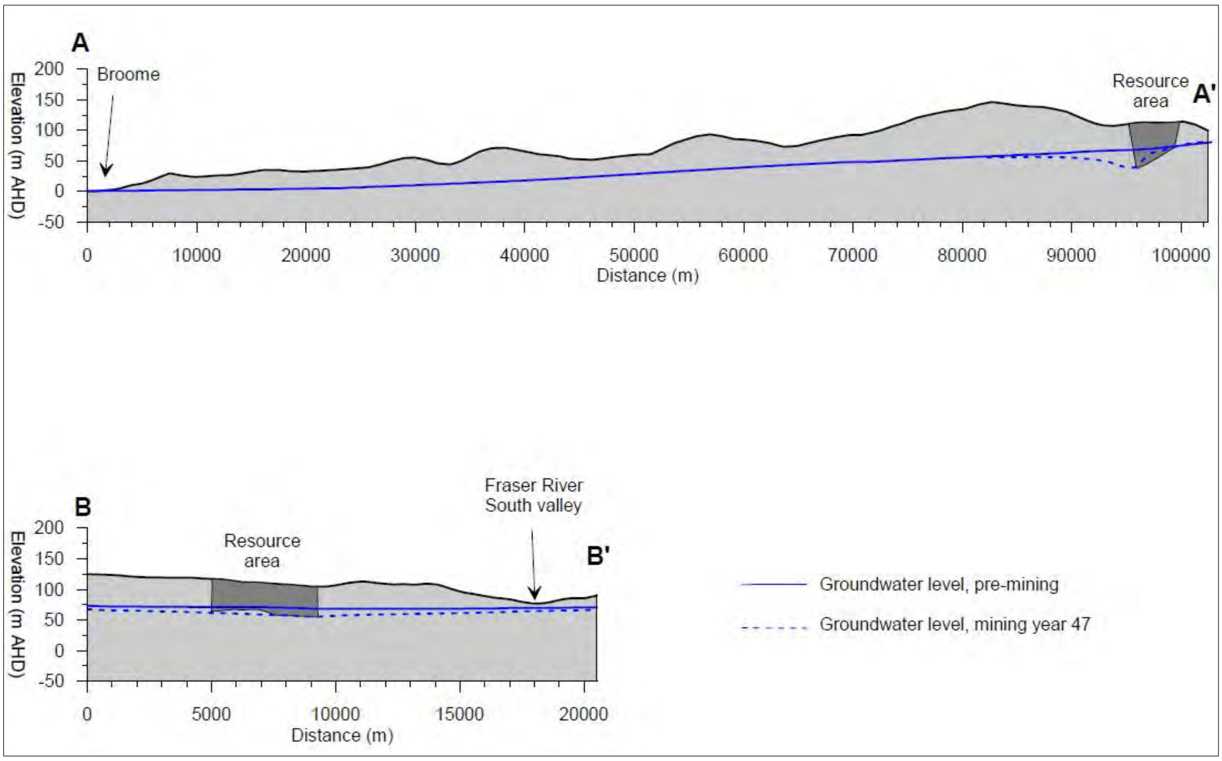
Localised Lowering or Rise of Groundwater Levels Causing Vegetation Decline in Groundwater Dependant Ecosystems

Drawdown of the groundwater table resulting from mine dewatering and abstraction is predicted to be contained largely within the mining lease and it is anticipated that any impact to nearby ecosystems, if this occurs, will be gradual and minimal. Several areas of vegetation associated with ephemeral waterlogging were noted during early investigations of the project area as potential GDEs, including intermittent 'soaks' to the southeast and northeast of the Mine Site Development Envelope. These areas are considered to be disconnected from or have limited connection to the aquifer to be targeted for abstraction (Section 4.2.5.5; Appendix 8), so will not be impacted by modelled drawdown (Table 61).

Vegetation community W14 in the Fraser River South valley to the south east of the mine area, is the only community identified as groundwater dependent due to the presence of *Eucalyptus camaldulensis* (Section 4.2.8.4; Appendix 8). The existing depth to groundwater in this area was interpolated to range from approximately 5 to 20 m below ground level (Appendix 8), and has a gradual modelled drawdown of approximately 2.7 m over the 32 year abstraction period (Table 61, Figure 46 and Figure 47).

Table 61: Summary of Modelled Drawdown and Mounding in the Vicinity of Interpreted Perched Groundwater Ecosystems

Assessment Area	Mining Year		
	Year 15	Year 32	Year 47
'Nearby Soak'	≤ 3.7 m	≤ 3.8 m	≤ 6 m
Fraser River South	~ 2 m	≤ 2.6 m	≤ 2.7 m



Section locations shown on Figure 46. Source: Rockwater 2016.

Figure 48: Hydrological Cross Sections Mining Year 47

As the area has a lower transmissivity basal transition unit (Rockwater 2016), the extent to which drawdown would affect vegetation is not certain. Given that modelled drawdown is not predicted to reduce groundwater levels below 10 to 12 m, the threshold at which a decline in health of *Eucalyptus camaldulensis* would be expected (after Colloff 2014), it is considered unlikely that adverse impacts to trees within the vegetation community would occur. Additionally, any adverse impacts are highly unlikely to impact on the distribution of the species as *Eucalyptus camaldulensis* occurs widely outside of the project area, across most of the Australian mainland (Chippendale 1988, DPaW 2016b).

Notwithstanding, a precautionary adaptive management approach is proposed to monitor vegetation and associated groundwater levels. Monitoring bores will be installed near Fraser River South and baseline groundwater monitoring will be conducted prior to the commencement of dewatering to provide further clarity around vegetation reliance on groundwater and any impacts of dewatering, should they occur. During abstraction, monitoring will continue, with trigger levels and mitigation measures implemented to maintain water levels should this area be shown to be impacted by groundwater drawdown. Part of the reinjection borefield could be relocated to maintain water levels in this area if required. These management measures are outlined in the Groundwater Management Plan (Appendix 24).

All groundwater abstraction, monitoring and reporting activities will be conducted in accordance with relevant regulatory permits and licences, and the volume of water abstracted will only be that required for safe mining operations. Flow meters will be fitted to groundwater extraction bores to enable monitoring of abstraction volumes.

The likelihood of groundwater level changes as a result of Project activities impacting on potential GDEs present in Fraser River South is 'Possible', however the consequence is considered as 'Minor' as modelled drawdown over the 32 year abstraction period is gradual. The potential residual impact on this community from changes in groundwater levels, after implementation of the management measures outlined in the Groundwater Management Plan, is assessed as 'Medium'.

Impact	Consequence	Likelihood	Residual Impact
Localised Lowering or Rise of Groundwater Levels Causing Vegetation Decline in Groundwater Dependant Ecosystems	Minor	Possible	Medium

8.3.2.2 Surface Water

Surface water flow volume within the Mine Site Development Envelope is inherently low due to high soil infiltration rates and low surface relief, with rainfall readily infiltrating through the soil, evident by the absence of any well-defined drainage channels within the mineral deposit area. The proposed location of all mine deposit and mineral separation plant infrastructure is within 5 km of the major drainage divide between the Fraser River South and Fraser River catchments and (other than the southernmost 500 m of the mineral deposit area) will only receive surface runoff from small local catchments.

While there are no visually discernible drainage lines requiring diversion, some of the project infrastructure lies over broad depressions which may be subject to waterlogging in wet conditions. The southernmost 500 m of the mineral deposit area extends across a broad valley receiving runoff from a catchment area of 108 km^2 which will require temporary diversion while that portion is being mined. The Site Access Road transverses an area of undulating terrain with drainage channels of the Fraser River South and Little Logue River catchments. During mining operations all surface runoff within the active mining area of up to 200 ha will be captured and used for process water.

Potential impact pathways for surface water regimes are:

- **Infrastructure causing localised reduction in surface water volumes.**
- **Infrastructure changing local drainage patterns and increasing flood risk.**
- **Surface water management structures causing localised erosion and sedimentation -** inappropriately engineered and constructed water management structures causing localised erosion and sedimentation surface of creek lines and drainage channels during rainfall events.

Impacts to surface water quality are discussed in Section 8.4. The assessed likelihood, consequence and residual impact (as per Section 7.3), is provided below for each potential impact.

Infrastructure Causing Localised Reduction in Surface Water Volumes

The only significant reduction in surface water volumes will be due to the capture of incident rainfall in the active mining area. This water will be captured in sumps and used as process water. The reduction in volume will be small as the mining area will be limited to approximately 200 ha (2 km^2) at any time. Surface flow from upstream of the active area will be diverted around the active mining area so only direct rainfall will be captured. The valley immediately south of the mineral deposit area has a catchment area of 108 km^2 so the impact of loss of runoff from 2 km^2 during mining operations will be incidental (<1%). The Fraser River South catchment at the Site Access Road is 369 km^2 so the impact of reduced volumes is likely to be undetectable at that point.

Surface water flows are inherently low due to high soil infiltration rates and low surface relief, with rainfall readily infiltrating through the soil. Due to diversion of upstream flows around the active mining area the impact is very small compared to the catchment area immediately downstream.

The local 'soak' 3 km southeast of the mineral deposit area will not be directly affected by surface runoff from operational areas and will not receive reduced surface water volumes. Further discussion on the impacts of surface water alteration on vegetation are discussed in Section 8.1.

Although some reduction in surface water volumes as a result of the mine excavation is considered 'Likely', this is expected to be localised and 'Incidental' in nature as it will affect any beneficial uses. The impact of infrastructure causing localised reduction in surface water volumes, after implementation of management measures, is assessed as 'Low'.

Impact	Consequence	Likelihood	Residual Impact
Infrastructure causing localised reduction in surface water volumes	Incidental	Likely	Low

Infrastructure Changing Local Drainage Patterns and Increasing Flood Risk

Other than the Site Access Road, proposed infrastructure areas are generally not subject to flood risk from large upstream catchments. Diversion drains or bunds will be put in place upstream of the active mining and process plant areas. The greatest flood risk is to the southernmost extent of the mineral deposit area, which encroaches on a broad ephemeral drainage line in the upper Fraser River South catchment with a catchment area of 108 km^2 which will require substantially larger diversion structures than the rest of the operations. No distinct channel can be seen; rather it is a wide valley exhibiting variation in vegetation associated with ephemeral drainage.

With regards to the Site Access Road, existing tracks have no engineered floodways or bridges/culverts at the crossing points with watercourses. Surface flow is able to pass over the track, but it is impassable during wet conditions. The Site Access Road will be upgraded to an all-weather road, with engineered drainage structures designed to allow natural flows to pass the road while maintaining all season access. The water pipeline to the reinjection borefield will be buried where it crosses tributaries of Fraser River South to ensure it does not impeded flow.

Very local changes to drainage patterns are considered 'Likely' at the location of infrastructure, but the construction of appropriate drainage measures will ensure the impacts are 'Incidental'.

Increased flood risk from construction of infrastructure is considered 'Possible' in at the southernmost extent of the mineral deposit area during large rainfall events. However, as flows would not be increased and suitable diversions and drainage measures in place, impacts would then be considered 'Incidental'. The potential impact on local drainage patterns and increased flood risk as a result of construction of infrastructure, after implementation of management measures, is 'Low'.

Impact	Consequence	Likelihood	Residual Impact
Infrastructure changing local drainage patterns	Incidental	Likely	Low
Infrastructure increasing flood risk	Incidental	Possible	Low

Surface Water Management Structures Causing Localised Erosion and Sedimentation

Increased sediment runoff and scouring may occur during clearing and through the incorrect installation of culverts and floodways. Concentrating flow and energy through culverts or over floodways can lead to erosion of both the upstream side of the culvert/floodway and of the downstream environment. Culverts and floodways will be installed in accordance with approved engineered design. Given the low flow volumes and high evaporation, any sediment runoff and scour is likely to be localised and managed through standard environmental management practices.

Localised erosion and sedimentation of creek lines and drainage channels caused by inappropriately engineered and constructed surface water management structures is considered 'Unlikely', with only minor and short term changes to surface water quality expected within the Mine Site Development Envelope that do not affect other surface water users. The potential residual impact of surface water management structures on localised erosion and sedimentation of creek lines and drainage channels, after implementation of management measures, is assessed as 'Low'.

Impact	Consequence	Likelihood	Residual Impact
Surface water management structures causing localised erosion and sedimentation	Incidental	Unlikely	Low

8.3.3 Management Measures

A summary of key measures to address potential impacts on surface water and groundwater is shown in Table 62. No other specific management measures are considered necessary.

Table 62: Proposed Management Measures for Hydrological Processes for the Mine Site Development Envelope

Potential Impact Requiring Management	Measures
Groundwater abstraction and dewatering causing localised changes in groundwater levels	• Recycling of water within the process water circuit will be implemented to minimise abstraction needs and water waste. • Monitoring bores will be established to assess potential groundwater drawdown and mounding impacts. This will included monitoring bores in the shallow strata of Fraser River South and Soak areas. • All groundwater abstraction, monitoring and reporting activities will be conducted in accordance with relevant permits and licences. • Only the volume of water required for ore processing and safe mining operations will be abstracted. • Flow meters will be fitted to groundwater abstraction bores to enable monitoring of abstraction volumes. • Process water storage facilities will be designed to minimise seepage.
Infrastructure causing localised reduction in surface water volumes. Infrastructure changing local drainage patterns and increasing flood risk.	• Roads and access tracks will be constructed with appropriate surface water drainage structures to minimise impacts on surface water flows. • Diversion bunds will be constructed around active mine pit areas to prevent surface water runoff from entering active mining areas. • Where necessary, suitable floodways, drains and culverts will be installed to transfer flow past infrastructure and return it to its natural flow path. • Pipelines will be buried when crossing watercourses to prevent impediment of flow.
Surface water management structures cause localised erosion and sedimentation	• Appropriately engineered surface water management structures will be constructed to redistribute flow downstream where no suitable natural channels are present.

8.3.4 Predicted Outcome

Drawdown of the groundwater table resulting from mine dewatering and abstraction from a water supply borefield is predicted to be contained largely within the mining lease and it is anticipated that any impact to nearby ecosystems, if this occurs, will be gradual and minimal. Drawdown impacts are not predicted to begin until after mining below the water table commences i.e. post Year 15. Monitoring bores are proposed as a precautionary measure, with trigger levels and mitigation measures implemented to maintain water levels should potentially groundwater dependant ecosystems associated with tributaries of Fraser River South be shown to be impacted by groundwater drawdown. Part of the reinjection borefield could be relocated to maintain water levels in this area if monitoring shows it is required.

The nearest licensed users and nearest registered Aboriginal heritage sites are unlikely to be affected as they are at least 30 km from the project, outside the modelled drawdown. There are no other major developments taking place surrounding the project and there will be no cumulative impacts on hydrological processes.

Given the paucity of watercourses within and near to the Mine Site Development Envelope, impacts to surface water flows from project infrastructure are likely to be minor and localised, and any associated erosion or sedimentation is expected to be highly localised.

Sheffield considers that the potential impacts of the project to hydrological processes will be able to be adequately managed such that the environmental objective for hydrological processes (Section 8.3) will be met, and that the residual impacts are therefore acceptable.

8.4 INLAND WATER QUALITY

The EPA's objective in relation to inland waters environmental quality is "*to maintain the quality of groundwater and surface water, sediment and biota so that the environmental values, both ecological and social, are protected.*"

8.4.1 Key Statutory Requirements, Environmental Policy and Guidance

Groundwater and surface water is protected by the following State legislation:

- *Rights in Water and Irrigation Act 1914 (WA).*
- *Country Areas Water Supply Act 1947 (WA).*
- *Environmental Protection Act 1986 (WA).*

In addition to State legislation, the following policy and guidance statements were considered in the impact assessment for inland water quality:

- EPA Position Statement No. 4, Environmental Protection of Wetlands (EPA 2004a).
- Australian and New Zealand Guidelines for Fresh and Marine Water Quality 2000 (Commonwealth) (ANZECC and ARMCANZ 2000).
- State Water Quality Management Strategy Document No. 6 (DoW 2004).
- Operational Policy No. 5.12, Hydrogeological Reporting Associated with a Groundwater Well Licence (DoW 2009).
- Water Quality Protection Guidelines No. 11, Mining and Mineral Processing, Mine Dewatering (DoW 2000).
- DoW Report No. 12, Western Australian Water in Mining Guideline. Water licensing delivery report series (DoW 2013).
- Water Quality Protection Guidelines for Mining and Mineral Processing (WRC 2000).
- National Water Quality Management Strategy (ARMCANZ and ANZECC 1995).
- Kimberley Regional Water Plan (DoW 2010).
- Guide to Departmental Requirements for the Management and Closure of Tailings Storage Facilities (DMP 2015).

The following documents were also considered:

- Kimberley Regional Planning and Infrastructure Framework (DoP and WAPC 2015)

8.4.2 Assessment of Potential Impact

Potential impacts of the Thunderbird Mineral Sands Project (the project) on inland water environmental quality are:

- **Exposure of contaminating materials causing contamination of surface water and groundwater** - Potentially Acid Forming (PAF) materials or other contaminating materials.
- **Accidental spills causing contamination of surface water and groundwater –** spills of chemical reagents and hydrocarbons may lead to contamination of surface water and groundwater.
- **Poor waste management causing contamination of surface water and groundwater** - at the wastewater treatment plant (WWTP) or landfill facilities.
- **Release of poor quality water causing contamination of surface water and groundwater** – release of poor quality water from the Tailings Storage Facility (TSF), water ponds and pipelines to natural drainage lines, particularly during periods of high rainfall.

Other potential impacts were screened out from further assessment (Section 7.4) as they were either assessed as not likely to occur or were unlikely to have any discernible consequence on any factor different to background levels:

Stressor	Justification for Exclusion
Erosion and sedimentation	Given the low gradient of the Mine Site, erosion is not considered to be a significant impact from the mineral deposit area. Although increased sediment runoff and scouring may occur during clearing and through the installation of incorrectly constructed culverts and floodways within the Mine Site Development Envelope, there are no defined surface water courses that will be impacted. Culverts and floodways will be installed in accordance with the approved engineered design.
Contamination of subterranean fauna habitat resulting in a loss of species diversity	Given the wide extent of the Broome Sandstone Aquifer across the Canning Basin, together with the lack of any significant obligate stygofauna identified within the study area and the relatively localised impact on aquifer saturated thickness, localised, minor contamination of groundwater will have incidental impacts on subterranean fauna (See Section 10.2.2).

The assessed likelihood, consequence and residual impact (as per Section 7.3), is provided below for each potential impact.

8.4.2.1 Exposure of Contaminating Materials Causing Contamination of Surface Water and Groundwater

Assessments of mine wastes and process residues (Appendix 19 and Appendix 20) was conducted to determine any risk of environmental contamination from excavation, backfilling and tailings storage of process materials, as well as exposure of acid forming materials as a part of the mining process. These assessments indicated that the significant majority of mine waste, including process residues, will be Non Acid Forming (NAF) and Barren with essentially no capacity for acid generation or acid neutralisation. Levels of soluble salts, metals and metalloids in any seepage from these materials will be extremely low, even under mildly acidic conditions.

Generation of potentially harmful acidic runoff through excavation or dewatering of acid sulfate soils (ASS) is therefore not considered a risk for the majority of the project materials. However, an apparent demarcation of sulfidic, Potentially Acid Forming (PAF) material was found to occur at a depth between 48.5 m (non-sulfidic) and 53.5 m (sulfidic) below the natural water table (approximately 85 m from ground surface), which will be approached in the final years of the proposed 47 year mine life. Consistent with a staged approach to soil investigations (DER 2015a), well ahead of planned mining and dewatering at depths which could disturb any of this material, further confirmation of the exact depth and extent of sulfidic material by additional more intensive regolith sampling and analysis will be conducted. Subsequent development of an appropriate mining strategy and sulfide soil management plan (DER 2015a and 2015b), including groundwater monitoring, will be implemented before any possible disturbance of material at this depth occurs. This includes consideration of the cone of depression resulting from mine dewatering.

Concentrations of water soluble elements of environmental significance in mine wastes and process residues were generally very low to non-detectable and below ANZECC livestock drinking water guidelines (only current beneficial use of groundwater), indicating that there is an extremely low risk of mine waste leachates from circum-neutral waters adversely impacting the surrounding environment by rainfall or groundwater interaction (TSF seepage).

Results from major ion analysis suggests that seepage from mine wastes and process residues will have extremely low levels of salinity, however the clay sized fraction (i.e. slimes from ore body processing) have the potential to be dispersive in nature, that when placed back into the initial TSF or mining excavation may result in supernatant water remaining highly turbid with suspended clay, limiting options for discharge of any excess mine water during high rainfall events.

For the majority of mine waste samples, dilute acid leach testing mobilised low levels of aluminium and iron, consistent with a natural presence of hydrated aluminium and iron oxides from weathering and groundwater interactions. Concentrations of all other environmentally significant metals and metalloids (including geochemically enriched thorium and selenium in various samples of mine waste and process residues) were extremely low in all samples and below corresponding ANZECC livestock drinking water guidelines. This is consistent with these metals and metalloids being held in highly insoluble and environmentally unavailable forms (particularly monazite). Such acidic conditions in any event are not expected to be possible in the significant majority of mine life and will be avoided by appropriate management at extreme depth towards the end of mine life.

As well as the leachate from the mined areas and wastes being, relatively environmentally benign, there will be no planned discharge of surface water from mining areas into the environment, either through surface water discharge or reinjection into groundwater. All drainage from the mine excavation will be directed into holding sumps and used for dust suppression, or used within ore processing.

Although the majority of leached solutions from mined wastes are thought to be chemically benign, to develop more robust understanding of site hydrology and hydrogeochemistry and the potential for potentially contaminating solutions to be transferred away from the Mine Site during later stages of mining, it is proposed that additional groundwater monitoring be conducted, including relevant chemical parameters within the Mine Site Development Envelope.

It is considered 'Unlikely' that even minor changes to surface water and groundwater quality in the project area watercourses would occur as a result of exposure of contaminating materials. Any changes that do occur with management and mitigation as above would not prevent the water from being used by livestock or fauna given the absence of harmful soluble contaminants in the waste materials. The potential residual impact of exposure of contaminating materials on surface water and groundwater quality, after implementation of management measures, is assessed as 'Low'.

Impact	Consequence	Likelihood	Residual Impact
Exposure of contaminating materials causing contamination of surface water and groundwater	Minor	Unlikely	Low

8.4.2.2 Accidental Spills Causing Contamination of Surface Water and Groundwater

Hydrocarbons and process reagents (acids, caustic and lime) will be used on site during the mining process and during ore processing. Diesel will be used as fuel for the mining fleet and will be refuelled from a purpose built fuel facility. Failure of material containment or equipment malfunction may potentially discharge these environmentally hazardous materials into the wider environment. Contamination of the wider environment through accidental mishandling or inadequate storage of materials will be avoided as far as practicable. Chemicals, hydrocarbons and other environmentally hazardous materials will be stored and handled in accordance with *Dangerous Goods Safety Act 2004* and associated regulations, including use of a bunded and sealed assembly area for hazardous chemicals (containerised) prior to offsite treatment/disposal, with leachates (if any) being collected in lined sumps and treated or containerised for disposal off site by a licenced and authorised waste contractor. Infrastructure will be periodically inspected and maintained to prevent failures into the wider environment.

Spills will be cleaned up and contaminated soils will either be remediated or removed from site by a licensed third party. Incident investigation will be undertaken as required to determine the cause of environmentally harmful spills/leaks and control measures identified to prevent future incidents. As required, spills will be reported to the relevant authorities.

Monitoring and assessment programs for surface and groundwater will be implemented as required and will include environmental quality analysis for parameters agreed with by regulatory authorities. Any deviations from agreed parameters will be investigated and control measures put in place.

It is considered 'Unlikely' that even minor changes to surface water and groundwater quality in the project area watercourses would occur as a result of accidental spills. Any 'Incidental' changes that may occur would not be expected to prevent the water from being used by livestock or fauna. The potential impact of exposure of accidental spills on surface water and groundwater quality, after implementation of management measures, is assessed as 'Low'.

Impact	Consequence	Likelihood	Residual Impact
Accidental spills causing contamination of surface water and groundwater	Incidental	Unlikely	Low

8.4.2.3 Poor Waste Management Causing Contamination of Surface Water and Groundwater

During normal operation of the WWTP, treated wastewater will be irrigated to an assigned area to infiltrate or evaporate, with no surface ponding or runoff. However, abnormal operation may cause excess nutrients and other contaminants within inadequately treated effluent outflow to enter the wider environment. Raised nutrient levels may favour the growth of introduced invasive weed species, as well as discourage the growth of native species not adapted to high nutrient loads. There are no defined drainage channels within the vicinity of the WWTP, mitigating any impacts to surface waters. Low levels of nutrients may infiltrate through the deep unsaturated profile to reach groundwater during rainfall events, however are not anticipated to be of a sufficient concentrations to be of concern.

The WWTPs will be constructed, operated and maintained in accordance with the Department of Environment Regulation (DER) Works Approval, Environmental Licence and local government and Department of Health regulations and permitting requirements as issued by the Shire of Broome. Effluent outflow produced by the WWTPs will either be irrigated to the environment or reused for dust suppression, and managed to allow effluent to infiltrate or evaporate and prevent surface ponding or runoff from the irrigation area. The WWTPs will be fitted with alarms and able to be shut down remotely should a failure occur. They will be regularly inspected, and discharge suspended if it is discovered they are operating below the required standard, with contingency storage capacity to be made available for up to two days of normal flow.

If allowed, access to food waste and other edible wastes within the onsite landfill may encourage and support populations of feral cats, dogs, and rodents who have the potential to transport litter into the wider environment. Additionally, inadequate fencing or containment of waste may lead to litter being blown outside the landfill boundaries. The landfill will be constructed and operated in accordance with the *Environmental Protection (Rural Landfill) Regulations 2002* under Prescribed Category 89 for a threshold of 'More than 20, but less than 5,000 t/a'.

A boundary fence will be erected to ensure an effective barrier is in place to prevent fauna access (specifically feral animals) and to create a wind barrier, with an entrance/exit gate incorporated, to be kept closed other than when waste is being deposited.

It is considered 'Unlikely' that even minor changes to surface water and groundwater quality in the project area watercourses would occur as a result of poor waste management. Any 'Incidental' changes that may occur would not be expected to prevent the water from being used by livestock or fauna. The potential residual impact of exposure of poor waste management on surface water and groundwater quality, after implementation of management measures, is assessed as 'Low'.

Impact	Consequence	Likelihood	Residual Impact
Poor waste management causing contamination of surface water and groundwater	Incidental	Unlikely	Low

8.4.2.4 Release of Poor Quality Water Causing Contamination of Surface Water and Groundwater

Water used in processing will be abstracted from the borefield to the south of the Thunderbird deposit and is not saline, however after use in processing, may contain low concentrations of environmentally hazardous materials. Failure of water infrastructure, such as pipelines or tailings storage facility, or overtopping during high rainfall events, may cause this water to be released into the wider environment. However, any streamflow leaving the Mine Site Development Envelope will be rapidly diluted by inflow from other catchments, effectively ameliorating impacts on some water quality parameters. There are no well-defined drainage channels within the area of the Thunderbird deposit and ore processing areas, where environmentally hazardous materials will be predominantly stored and used. Groundwater within the underlying strata is deep (greater than 20m), and localised surface contamination is unlikely to seep to groundwater in any significant concentrations.

A lined Process Water Dam will be constructed in order to store water from mine dewatering operations and process water from the borefield. Water in this dam will be used for either dust suppression on the roads within the mineral deposit area, or reused within the WCP. All HDPE-lined ponds shall be designed to have a controlled release point to prevent over topping and sufficient freeboard will be maintained in water storages to allow capture of rainfall from a one in one hundred year 72 hour ARI (average recurrence interval) event.

As discussed under Section 10.3.2.3, mine waste materials, including process residues, are environmentally benign. Should an ore delivery pipe from the MUP to the WCP or a tailings pipe burst between the processing plant and initial TSF or mine void, automatic shutoff valves will minimise loss to the environment. Any spilt process residue material will be collected and placed in the initial TSF or as backfill within the mined areas.

Likelihood of failure of the TSF and release of its contained supernatant and slurries into the wider environment will be reduced by a detailed design compliant with the *Code of Practice for Tailings Storage Facilities in Western Australia* (DMP 2013) and *ANCOLD Guidelines on Tailings Dam Planning, Design, Construction, Operation and Closure* (2012). The proposed materials for construction of the TSF have undergone geotechnical assessment, and have been deemed suitable for TSF construction.

Characterisation of mine wastes and process residues identified that tailings supernatant is likely to be highly turbid due to potentially dispersive material within the tailings. Biodegradable flocculant will be used to manage turbidity within process water and tailings supernatant to assist in settling of suspended clay/silt material to allow for re-use in the processing plant.
It is considered 'Unlikely' that even minor changes to surface water and groundwater quality in the project area watercourses would occur as a result of accidental release of poor quality water. Any 'Incidental' changes that may occur would not be expected to prevent the water from being used by livestock or fauna. The potential residual impact of exposure of accidental spills on surface water and groundwater quality, after implementation of management measures, is assessed as 'Low'.

Impact	Consequence	Likelihood	Residual Impact
Release of poor quality water causing contamination of surface water and groundwater	Incidental	Unlikely	Low

8.4.3 Management Measures

A summary of key measures to address potential impacts on inland water quality is shown in Table 63. No further specific management measures for inland water quality are considered necessary.

Table 63: Proposed Management Measures for Protection of Inland Water Quality for the Mine Site Development Envelope

Potential Impact Requiring Management	Measure
Exposure of contaminating materials causing contamination of surface water and groundwater	• Prior to commencement of mining below the water table, additional ASS sampling and analysis of potentially sulfidic material at depth within the mine deposit area will be undertaken. • If additional sampling indicates potential issues with ASS, a Management Plan will be developed and implemented. • Conduct groundwater monitoring for groundwater levels and quality within the Mine Site Development Envelope. • Water collecting in the mining excavation will be directed into holding sumps and used for dust suppression or ore processing.
Accidental spills causing contamination of surface water and groundwater	• Refuelling and fuel delivery inlets will be located on concrete or HDPE-lined pads to contain any drips and spills. The pads will drain to a sump to allow removal of collected material. • A bunded and sealed assembly area for hazardous chemicals (containerised) prior to offsite treatment/disposal will be established. • Transformer stations will be in bunded areas which meet the requirements of Australia Standards AS1940, AS 2067 and AS 3007. • The power station day tank, waste oil tank and lubricants will be located in a bund that complies with Australian Standards AS1940 and AS1692. • All hydrocarbon and chemical storages will be designed and constructed in accordance with Australian Standards AS1940 and AS1692 • Equipment and vehicles including surface mobile equipment shall be subject to a regular maintenance program to reduce the likelihood of spills and leakages occurring. • Heavy, light vehicle and maintenance workshop facilities will be located on concrete pads and hydrocarbon spillages and leakages captured and appropriately managed through the use of hydrocarbon absorbent materials • Spill kits will be located at strategic locations throughout the project area and employees trained in their use. • Hydrocarbon wastes will be segregated from other wastes and collected for offsite disposal by a licensed contractor. • The transport, storage or use of any designated Dangerous Good or substance will be conducted in accordance with Dangerous Goods permits as required and in accordance with Dangerous Goods Safety Act 2004, Dangerous Goods Safety (Road and Rail Transport of Non-Explosives) Regulations 2007 and Dangerous Goods Safety (Explosives) Regulations 2007.

Potential Impact Requiring Management	Measure
	• Monitoring and assessment program for surface and groundwater will be implemented as required and will include environmental quality analysis for parameters agreed with by regulatory authorities. • Spills will be contained, remediated, investigated and reported to the relevant authorities as required.
WWTP: poor waste management causing contamination of surface water and groundwater	• WWTP will be constructed, operated and maintained in accordance with the Department of Environment Regulation (DER) Works Approval, Environmental Licence and local government and Department of Health regulations and permitting requirements as issued by the Shire of Broome. • Effluent produced by the WWTPs will either be irrigated to the environment or reused for dust suppression. • The WWTP will be fitted with alarms and be able to be shut down the plant should a failure occur. • WWTPs will be regularly inspected and discharge suspended if it is discovered they are operating below the required standard. • The WWTP will have contingency storage capacity for up to two days of normal flow if discharge is suspended while any problems are addressed. • Effluent discharge from the WWTP will be managed to allow effluent to infiltrate or evaporate and prevent surface ponding or runoff from the irrigation area.
Landfill facilities: poor waste management causing contamination of surface water and groundwater	• Domestic wastes will be disposed of into a purpose built onsite landfill. • The landfill will have a boundary fence to prevent fauna access (specifically feral animals) and to create a wind barrier. • An entrance/exit gate within the boundary fence will be kept closed other than when waste is being deposited. • Recyclable wastes will be collected in a laydown area and transported offsite for recycling.
Release of poor quality water causing contamination of surface water and groundwater	**Water Storages:** • A lined Process Water Dam will be constructed in order to store water from mine dewatering operations and process water from the borefield. • All HDPE-lined ponds shall be designed to have a controlled release point to prevent over topping. • Sufficient freeboard will be maintained in water storages to allow capture of rainfall from a one in one hundred year 72 hour ARI event. • Water in the Process Water Dam will be reused within the WCP. **Initial TSF/Backfill** • Detailed TSF design compliant with the Code of Practice for Tailings Storage Facilities in Western Australia (DMP 2013) and ANCOLD Guidelines on Tailings Dam Planning, Design, Construction, Operation and Closure (ANCOLD 2012). • A biodegradable flocculent will be used to assist in settling of suspended clay/silt material from process water.

8.4.4 Predicted Outcome

The potential to generate environmentally harmful acidic runoff through excavation or dewatering of acid sulfate soils (ASS) is not considered a risk for the majority of the project materials. However, samples of material found at depth within the mine deposit area were considered PAF and may be reached in the final years of the proposed

47 year mine life. These materials will be further defined and managed through developed management plans at a suitable point in the life of the mine.

Any contaminated flow leaving the Mine Site Development Envelope will be rapidly diluted by inflow from other catchments, effectively ameliorating impacts on some water quality parameters. Additionally, there are no defined water course channels within the mine deposit and ore processing plant areas, where environmentally hazardous materials and processes will be predominantly stored and used. Groundwater within the underlying strata is deep (≥ 20m), and localised surface contamination is unlikely to seep to groundwater in any significant concentrations.

There are no other major developments taking place surrounding the project, hence there will be no cumulative impacts on inland water quality.

Sheffield considers that the potential impacts to inland water quality will be able to be adequately managed such that the environmental objective for inland environmental quality (Section 8.4) will be met, and that the residual impacts are therefore acceptable.

8.5 HERITAGE

The EPA's objective in relation to heritage is "*to ensure that historical and cultural associations, and natural heritage, are not adversely affected*".

8.5.1 Key Statutory Requirements, Environmental Policy and Guidance

Both Commonwealth and State legislation apply to the protection of Aboriginal heritage:

- *Aboriginal Heritage Act (1972) (WA).*
- *Aboriginal and Torres Strait Islander Heritage Protection Act 1984 (Cth).*
- *Native Title Act 1993 (Cth).*

In addition to Commonwealth and State legislation, the following policy and guidance statements were considered in the impact assessment for Aboriginal heritage:

- Department of Aboriginal Affairs and Department of Premier and Cabinet (DAA & DPC) 2013. *Aboriginal Heritage – Due Diligence Guidelines, Version 3.0.*
- EPA, 2004e. Assessment of Aboriginal Heritage. *Guidance for the Assessment of Environmental Factors No 41*.
- Department of Aboriginal Affairs guidelines regarding Section 18 and risk assessment (DAA 2013)

8.5.2 Assessment of Potential Impact

The potential impacts to Aboriginal heritage from the project are:

- **Ground disturbance causing impacts to known Aboriginal heritage sites and landscape cultural values.**
- **Ground disturbance causing impacts to unknown Aboriginal heritage sites.**
- **Project activities causing impacts to groundwater and groundwater dependent ecosystems.**

8.5.2.1 Ground Disturbance Causing Impacts to Known Aboriginal Heritage Sites and Landscape Cultural Values

Sheffield has worked closely with Traditional Owners since 2012 to survey the project area to ensure its activities have avoided Aboriginal sites and areas of Aboriginal cultural value. Prior to these surveys and work undertaken by the previous tenement owner, no formal heritage surveys have been conducted for the project area or immediate surrounds.

Searches of relevant government databases identified that there are no registered Aboriginal sites or other heritage places of significance located within the Mine Site Development Envelope.

Aboriginal sites and areas of Aboriginal cultural value (not registered with the Government) have been identified and mapped within the mining operations area and surrounds (Section 4.2.13.1). Buffer zones have been determined by the Traditional owners to protect these places. Project design has considered these and land disturbance has been located outside these. The majority of the Mine Site Development Envelope is located on flat terrain away from rocky outcrops, water sources and areas of good ground surface visibility that are known to be associated with Aboriginal heritage sites in the region.

It is considered very 'Unlikely' that the project will adversely affect known historical and cultural associations, or natural landscape heritage values, and any potential impacts would be 'Minor'. The potential residual impact of ground disturbance on known Aboriginal heritage sites, after implementation of management measures, is assessed as 'Low'.

Impact	Consequence	Likelihood	Residual Impact
Ground disturbance causing impacts to known Aboriginal heritage sites and landscape cultural values	Minor	Unlikely	Low

8.5.2.2 Ground Disturbance Causing Impacts to Unknown Aboriginal Heritage Sites

Aboriginal heritage surveys have been systematic (covering the entire project footprint from the air and on-ground) and targeted in areas with the greatest potential for Aboriginal sites to occur, such as water sources and topographic features. All known sites and areas likely to contain sites were considered, however it is noted that parts of the mining operations area are densely vegetated, precluding intensive pedestrian survey from those areas.

Although the mine site layout and footprint will be designed such that it adheres to buffer zones and identified sites and areas of Aboriginal cultural value, there is potential that isolated archaeological material, or Aboriginal ancestral remains, could be found in these areas. Sheffield has therefore developed contingency measures in the way of procedures and protocols should discovery of new Aboriginal cultural material or ancestral remains be made at any time during construction or operation of the project. These contingency measures are outlined in the Aboriginal Heritage Management Operations Framework document (Appendix 26).

It is considered very 'Unlikely' that the project will adversely affect unknown historical and cultural associations. The consequence of any impacts to unknown sites is considered to be 'Minor'. The potential residual impact of ground disturbance on unknown Aboriginal heritage sites, after implementation of management measures, is assessed as 'Low'.

Impact	Consequence	Likelihood	Residual Impact
Ground disturbance causing impacts to unknown Aboriginal heritage sites	Minor	Unlikely	Low

8.5.2.3 Project Activities Causing Impacts to Groundwater and Groundwater Dependent Ecosystems

Consultation with Traditional Owners identified that impacts to groundwater and groundwater dependant ecosystems were of concern. The nearest potential groundwater dependent ecosystem is in the low-lying areas associated with Fraser River South, about 10.5 km southeast of the mine, intersecting the Site Access Road.

Potential impacts of the project on groundwater dependent ecosystems and management measures are detailed in Section 8.1.2.

8.5.3 Management Measures

Since 2012 Sheffield has consulted with Traditional Owners from all Native Title groups in the project area, and amassed comprehensive information regarding Aboriginal sites and cultural heritage values in the project area. This has enabled Sheffield to adhere to its general management approach of avoidance and minimisation of impacts to Aboriginal heritage.

The management approach undertaken by Sheffield for the project is to avoid where possible and minimise where practicable impacts to important Aboriginal heritage through engagement with Traditional Owners, project design and use of appropriate management measures. Proposed management measures for protection of Aboriginal heritage are provided in Table 64.

Table 64: Proposed Management Measures for Protection of Heritage in the Mine Site Development Envelope

Potential Impact Requiring Management	Measure
Ground disturbance causing impacts to known Aboriginal heritage sites and landscape cultural heritage values	• Development and implementation of Aboriginal Heritage Management Operations Framework and Cultural Heritage Management Plan (see below). • Maintain buffer zones around important Aboriginal sites and areas with Aboriginal heritage values in the Mine Site footprint and surrounds. • Maintain consultation with Traditional Owners. • Disturbance of Aboriginal heritage sites to be consistent with agreements with Native Title claimants and Aboriginal Heritage Act 1972.
Impacts to unknown Aboriginal heritage sites as a result of ground disturbance	• Develop and implement procedures for discovery of new Aboriginal heritage cultural materials (Aboriginal Heritage Management Operations Framework). • Conduct additional surveys in consultation with Traditional Owners where required.
Impacts to groundwater and groundwater dependent ecosystems	See Section 8.3.3 Hydrological Processes Management Measures for impacts to groundwater.
Native Title	• Sheffield is seeking a Mining Agreement with the Native Title claimant.

The project will be constructed and operated in accordance with an Aboriginal Heritage Management Operations Framework. This Framework provides an overview of measures and controls that will be implemented to ensure Aboriginal heritage is managed effectively through the life of the project. The Framework will provide a reference for Sheffield employees and contractors and will assist Sheffield and its contractors to operate within an environment where important sacred and cultural material places occur close to key construction and operational areas.

The Framework details standards and procedures in relation to the following:

- Discovery of cultural material.
- Discovery of Aboriginal ancestral remains.
- Operating in proximity to a buffer zone.
- Cultural monitoring during future works.
- Incident reporting.
- Compliance with the *Aboriginal Heritage Act 1972*.

The Framework measures are consistent with the provisions of agreements made, and that are under negotiation, with the Native Title party.

Sheffield will work closely with Traditional Owners to prepare a Cultural Heritage Management Plan (CHMP) for the project. The CHMP will detail long term management requirements for specific places and sites that are not limited to the mining operations area, identified through further consultation with Traditional Owners. It will detail Sheffield's contribution to longer term management of important and significant Aboriginal sites and places, through:

- Identification of management requirements for specific sites and places with important Aboriginal heritage vales, for example site stabilisation works, access rationalisation, erosion control.
- Protocols for Traditional Owners to access and care for sacred sites.
- Identification of management measures for Aboriginal cultural values associated with the environment, such as ground water health.
- Identification of opportunities for collaboration with Traditional Owners to promote and enrich Aboriginal culture and heritage, for example interpretive material, oral history recording and intergenerational site visits.
- Identification of opportunities for training and capacity building for Aboriginal people in the project area.

8.5.4 Predicted Outcome

Database searches found no Aboriginal heritage or other heritage places on the Register of Aboriginal sites (Section 4.2.13.1) within the Development Envelope. The Mine Site Development Envelope has been surveyed by Traditional Owners, and all (unregistered) culturally important areas have been identified and mapped. Buffer zones have been defined to protect known heritage sites or culturally important areas within the Mine Site Development Envelope.

There is a possibility that unknown archaeological heritage sites or ancestral remains within the Mine Site Development Envelope may be found, however, Sheffield are effectively managing this through implementation of the Heritage Management Framework (Appendix 26) and a Heritage Management Plan to be developed with Traditional Owners. It is anticipated that this will eliminate the prospect of any inadvertent damage to these findings.

Any impact to known Aboriginal heritage will only occur in accordance with agreements reached with the Native Title claimants and the *Aboriginal Heritage Act 1972*.

Sheffield considers that the potential impacts to heritage will be adequately managed such that the objective for heritage (Section 8.5) will be met, and that the residual impacts are therefore acceptable.

9. ENVIRONMENTAL IMPACT ASSESSMENT - KEY ENVIRONMENTAL FACTORS - PORT DEVELOPMENT ENVELOPE

Key environmental factors for the Derby Port Development Envelope comprise the following:

- Marine Environmental Quality.
- Amenity.

Potential impacts for the key environmental factors are detailed in Sections 9.1 and 9.2.

Potential impacts to the Town of Broome and the Port of Broome were screened out from further assessment (Section 7.4) as they were either assessed as not likely to occur or were unlikely to have any discernible consequence on any factor different to background levels:

Stressor	Justification for Exclusion
Installation of mooring points affecting turbidity	No mooring points are required for the Port of Broome; vessels will use the existing Port of Broome wharf infrastructure.
Product dust or spillage causing marine pollution	Packaged products to be transferred to ocean-going vessels will not be opened and thus the likelihood of spillage in the marine environment is considered rare and the consequences insignificant given the small volume of each package and inert nature of the products.
Radiation impacting on the marine environment	Products to be exported from the Port of Broome will be packaged. Specific activity concentrations will be above 1 Bq/g, but below 10 Bq/g meaning that they meet the definition of a radioactive substance, however are of insufficient specific activity that their transport requires regulation. The likelihood of spillage of packaged material into the marine environment is considered rare given the loading method and the consequences of short term spillage insignificant given the small volume of each package and the inert nature of the products. Any significant incidents of spillage of packaged materials will be recovered (e.g. suction dredging) for re-processing.
Hydrocarbon spill causing marine pollution	Refuelling of vessels in the Port Area will not be required as ocean going vessels will refuel in their home port. This makes the likelihood of a hydrocarbon spill extremely unlikely.
Dust or noise emissions causing a decrease in amenity for sensitive receptors	Products to be transported will be packaged minimising the likelihood of spillage or dust generation during transport. Transport of product to the Port of Broome will be along the dedicated heavy vehicle bypass route (Gubinge Road and Port Drive). As transport vehicles will bypass the town of Broome, and will be on a dedicated heavy vehicle road that is currently under utilised compared to design criteria, significant additional impacts to amenity are considered unlikely.

9.1 MARINE ENVIRONMENTAL QUALITY

The EPA's objective in relation to marine environmental quality is "*to maintain the quality of water, sediment and biota so that the environmental values, both ecological and social, are protected*".

9.1.1 Key Statutory Requirements, Environmental Policy and Guidance

The key legislation relating to managing impacts on marine environmental quality in Western Australia includes:

- *Environmental Protection Act 1986 (WA).*

In addition to State legislation, the following policy and guidance statements were considered in the impact assessment for marine environmental quality:

- Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC & ARMCANZ 2000).
- Code of Practice and Safety Guide for Radiation Protection and Radioactive Waste Management in Mining and Mineral Processing (ARPANSA 2005).
- Code of Practice for Safety Transport of Radioactive Material (ARPANSA 2008).
- Safety Guide, Safe Transport of Radioactive Material (ARPANSA 2008).
- Environmental Assessment Guideline 15. Protecting the Quality of Western Australia's Marine Environment (EPA 2015e).
- State Water Quality Management Strategy No. 6. Implementation Framework for Western Australia for the Australian and New Zealand Guidelines for Fresh and Marine Water Quality and Water Quality Monitoring and Reporting (Guidelines Nos. 4 & 7: National Water Quality Management Strategy). (DoW 2004).
- State Planning Policy 2.6 State Coastal Planning. (WAPC 2013).

9.1.2 Assessment of Potential Impact

Marine water quality in King Sound is characterised by naturally high levels of turbidity due to the discharge of the Fitzroy River and various other oceanographic processes (existing marine quality is described in Section 6.2.11.3). Indicative water sampling shows that turbidity in the area of the Derby Port Development Envelope is 62 NTU and suspended solids concentrations are also very high (89 mg/L). Other general parameters of salt content and salt composition are consistent with typical seawater.
This assessment focuses on impacts to marine water quality and sediment. Impacts to marine biota are assessed in Section 11.1 Benthic Habitats and Communities, and Section 11.2 Marine Fauna.

Potential impact pathways for marine water quality are:

- **Installation of mooring points increasing turbidity** - increase in turbidity through installation of mooring points with the Derby Port limits at the wharf mooring zone and the sea transfer point.
- **Product dust or spillage causing marine pollution** - dust or spillage of product from transfer and transhipment causing marine water and sediment pollution.
- **Hydrocarbon spill causing marine water and sediment pollution** - impact through spillage of hydrocarbons.
- **Radiation impacting the marine environment** – impact through spillage or dust of radioactive product entering marine environment.

Other potential impacts were screened out from further assessment (Section 7.4) as they were either assessed as not likely to occur or were unlikely to have any discernible consequence on any factor different to background levels:

Stressor	Justification for Exclusion
Uncontrolled drainage from the Product	Marine pollution will not be caused through uncontrolled drainage from the product export facility, which will either be a fully enclosed, concrete floored and internally

Stressor	Justification for Exclusion
Storage Facility	draining shed or silo facilities. Drainage within the shed will be directed to sumps. Materials collected in the sumps will be periodically removed as needed and returned to the Mine Site for reprocessing. Shed doors will only open to allow entry and exit of road trains. Mineral sands products to be stored at Derby Port are insoluble and considered environmentally benign. No impact to marine water quality is expected from this stressor and no monitoring is considered necessary.

The assessed likelihood, consequence and residual impact (as per Section 7.3), is provided below for each potential impact.

9.1.2.1 Installation of Mooring Point Affecting Turbidity

Several mooring points are required for the project; these will be located at the wharf mooring zone (for tug boats and transhipment vessels) and near Point Torment for ocean-going vessels (the sea transfer point). These moorings will be located in the same general area as existing mooring facilities used by the former Lennard Shelf Pty Ltd operation. Information from DoT indicates some or all of these moorings need to be upgraded or replaced.

The upgrade process is expected to cause minor localised increase in turbidity as the moorings are installed. Some ongoing additional turbidity is expected as the mooring lines will drag on the seafloor in low tides. Although it is possible that benthic invertebrate and burrowing organism habitat could be present in the area, there are no known seagrasses or corals within the Port limits (Section 4.3.13.2). Any benthic communities in the area would be naturally adapted to extremely high and fluctuating levels of turbidity and any additional turbidity will be localised to the immediate vicinity of the moorings. The disturbance caused by this upgrade is expected to be negligible.

Additional turbidity is considered 'Likely' to be generated within the Port limits from the installation of new moorings, however it will be short term, localised and the large tidal exchange will ensure water quality remains close to normal levels. The potential residual impact of the installation of mooring points on marine environmental quality, after implementation of management measures, is assessed as 'Low'.

Impact	Consequence	Likelihood	Residual Impact
Installation of mooring point affecting turbidity	Incidental	Likely	Low

9.1.2.2 Product Dust or Spillage Causing Marine Pollution

The mineral sands products to be exported have limited potential for dust generation as they have a high specific gravity, are granular in nature, and contain limited fines. They do not contain contaminants such as heavy metals, hydrocarbons or acids. While being slightly radioactive, their low levels of radiation do not require regulation under the *Radiation Safety Act 1975* for the purpose of transport, storage and export.

The product storage facility to be constructed at the Derby Port will store up to 50,000 to 60,000 tonnes of mineral sands products. It will be purpose designed and may be either a shed structure or silos. The shed would be fully enclosed to prevent dust escaping and will accommodate all unloading and storage activities. Road trains will drive through the shed and tip into a specific product drop area.

During transhipment vessel (barge) loading operations, a front end loader will feed a hopper connected to a conveyor system running the length of the storage facility. From there, the mineral sands products are fed into the existing transhipment vessel loading conveyor. This conveyer system is covered to minimise loss or spillage of product, and has been used successfully in the past by Lennard Shelf Pty Ltd. The loading conveyor will be retained, and prior to commencing operations the head chute, conveyor belt and various other key components will be replaced, ensuring optimum working order of this existing infrastructure.

Once on the transhipment vessel, side skirts will minimise any loss of dust. After loading to the ship, the mineral sands products will be fully enclosed in readiness for transport to international markets.

Although the spillage of product or product dust is considered ‘Likely’, it is also considered that it will not result in any discernible changes to the quality of water, sediment or biota in King Sound or adjacent waters. Mineral sands products are environmentally benign and would not cause contamination in the event of a spill. The potential residual impact from product dust or spillage on marine environmental quality, after implementation of management measures, is assessed as ‘Low’.

Impact	Consequence	Likelihood	Residual Impact
Product dust or spillage causing marine pollution	Incidental	Likely	Low

9.1.2.3 Hydrocarbon Spill Causing Marine Pollution

The ocean-going vessel will be refuelled in its home port with no need to refuel in Western Australian waters. All ships greater than 400 Gross Tonnes are required to have their own Ship Oil Pollution Emergency Plan and basic oil spill equipment, as per Regulation 37 of MARPOL Annex I.

The Sheffield tugs will operate on diesel fuel, as would motorised transhipment vessels should these be used. No refuelling infrastructure is permanently sited on the wharf, and refuelling of tugs will take place via mobile refuelling trucks. This is the standard methods employed at Derby Port and meets the accepted criteria of the Department of Transport (DoT) and other government departments. This method has been used historically for the operation of the Derby Port without incident and the expected risk is low. The mobile refuelling infrastructure is equipped with an emergency shutdown valve and the process will be monitored by experienced personnel at all times.

All Sheffield owned or operated tug boats will be maintained to high standards as required by DoT (the company operating the ocean-going vessel will be responsible for appropriate and regular maintenance checks of that vessel).

Should a minor spill of diesel occur, this is unlikely to pose significant risk to the environment. When spilt into the warm tropical and subtropical marine environments, diesel spreads rapidly and forms a very thin slick, with most of the more volatile components typically evaporating in less than a day. Of the remaining unevaporated volume, a large proportion may partition into the water column. Typically, less than 50% of the slick volume, and potentially far less, will remain on the water surface after 24 to 48 hours. The Port of Derby has spill equipment on standby should a spill occur, and Sheffield will liaise with the Port of Derby to ensure the spill equipment is in working order before commencement of operations. In addition, an appropriately sized and stocked marine spill kit will be located on each Sheffield owned or operated tug boat to allow management of small scale spillages. Any spills of oil, fuel or other hydrocarbons to water will be immediately reported to DoT for advice.

Any used oil or oil-soaked absorbents will be securely stored and then properly disposed of at an appropriate licensed facility to reduce the chance of oil, fuel or any oily wastes being discharged into the marine environment. Management of hydrocarbons and potential spills is addressed in the Port Environmental Management Plan.

The spillage of hydrocarbons is considered ‘Possible’ during refuelling operations, however volumes will be minimal due to the management measures proposed, and will not result in any discernible changes to the quality of water, sediment or biota in King Sound or adjacent waters. The potential residual impact from the spillage of hydrocarbons on marine environmental quality, after implementation of management measures, is assessed as ‘Low’.

Impact	Consequence	Likelihood	Residual Impact
Hydrocarbon spill causing marine pollution	Incidental	Possible	Low

9.1.2.4 Radiation Impacting the Marine Environment

The radioactivity levels of naturally occurring radioactive materials (NORMs) in the majority of exported products is less than 10 Bq/g with the primary product by volume (ilmenite) having an activity of less than 1 Bq/g (0.59 Bq/g Radiation Professionals 2016, Appendix 21). The HiTi88 product has a marginally higher radioactivity at 1.52 Bq/g. Both of these products are below screening values of any potential modelling that may be required in the future. Zircon concentrate has the highest level of radiation at 9.10 Bq/g, but represents only 14.22% of the material exported (8,227 tpa in Stage II).

In accordance with Australian Radiation Protection and Nuclear Safety Agency (ARPANSA 2005) and International Atomic Energy Agency Safety Guide RS-G-1.7 (IAEA 2004), materials containing NORMs are excluded from regulations and considered inherently safe if the specific activity concentrations are below 1 Bq/g (ARPANSA 2005). Concentrations of NORM up to 10 Bq/g are generally considered exempt in relation to transport restrictions due to the nature of the materials and form of radiation primarily emitted (alpha rather than gamma). The potential impact to the marine environment from naturally occurring radioactive materials is therefore extremely small and will not require special consideration and management.

Minor spillages of low radioactivity ilmenite or HiTi88 would be of negligible impact to the marine environment of King Sound. In the unlikely event of a major spill, recovery of the product by suction dredging and return of the material to the Mine Site for re-processing is considered adequate.

There is potential for minor impact to the marine environment from significant spillage without appropriate cleanup of the zircon products, in particular the zircon concentrate. Due to the small volume nature and transport requirements of the zircon products, these materials will be packaged (likely bulka bags) and hence not subject to dusting potential. If a bag is split or lost over the side of a vessel or wharf, recovery of the zircon with a suction dredge and return to the Mine Site for re-processing is considered an appropriate response in conjunction with validation testing of remaining sediment to ensure levels of radiation have returned to established background levels. Short term exposure of marine organisms within a very limited spatial area during this process to low levels of activity is not considered to be of significant impact. All products have a specific gravity higher than 4.7 and are therefore denser than the silty or quartz based sediment (ca. 2.6). As such, they will not disperse readily with water even in the high tidal range and any spillage would be localised and tend to sink down through the sediment profile away from where marine biota might be exposed to them.

A Radiation Monitoring Program will be implemented in accordance with the Radiation Management Plan (RMP) in consultation with Radiological Council and Department of Mines and Petroleum. The RMP will define the requirements for periodic monitoring for both personal and environmental monitoring of radiation levels. This will include establishment prior to operations of background soil, sediment and airborne dust samples.

The products have very low to insignificant levels of natural radiation and are considered ‘Unlikely’ to result in impacts to marine water, sediment or biota. The potential residual impact from radiation on marine environmental quality, after implementation of management measures, is assessed as ‘Low’.

Impact	Consequence	Likelihood	Residual Impact
Radiation impacting the marine environment	Incidental	Unlikely	Low

9.1.3 Management Measures

A summary of key measures to address potential impacts on marine environmental quality is shown in Table 65.

Table 65: Proposed Management Measures for Protection of Marine Environmental Quality

Potential Impact Requiring Management	Measure
Installation of mooring points affecting turbidity	• Sheffield will either upgrade or replace existing moorings installed at transhipment vessel and ship loading points within Derby Port limits.
Product dust or spillage causing marine pollution	• The Product Storage Facility will include a drive through enclosed unloading area to ensure product is contained within facility during unloading activities. • Transfer of product to the barge will be via a covered conveyor to minimise escape of dust or spillage.
Hydrocarbon spill causing marine pollution	• Refuelling of marine vessels will be consistent with Port of Derby requirements. • Used oil or oil-soaked absorbents will be securely stored and disposed of at a licensed facility to reduce the chance of oil, fuel or any oily wastes being discharged into the marine environment. • Refuelling equipment will include emergency shutdown valve and be monitored at all times. • Spills of oil, fuel or other hydrocarbons to water will be immediately reported to DoT for advice. • A spill kit located at Derby Port will be maintained in working order. • An appropriately sized and stocked marine spill kit will be located on each Sheffield owned or operated tug boat to address small scale spillages. • Management of hydrocarbons and potential spills is addressed in the Port Environmental Management Plan.
Radiation impacting the marine environment	• Background radiation levels in soil, sediments and airborne dust will be measured prior to construction commencing. • Spillages of product on land will be cleaned up as required. Spilt product will either be returned to the Product Storage Facility or returned to the Mine Site for reprocessing or disposal.

9.1.4 Predicted Outcome

King Sound is a highly dynamic environment with very high turbidity which occurs naturally as a result of the Fitzroy River and other oceanographic processes. Any additional turbidity generated from the installation of new moorings will be short term, localised and the large tidal exchange will ensure water quality remains close to baseline levels.

Some minor generation of dust or spillage of product is likely throughout the life of the project; however, it is considered that it will not result in any discernible changes to the quality of water, sediment or biota in King Sound or adjacent waters. Mineral sands products occur naturally in King Sound and are environmentally benign.

The spillage of hydrocarbons is possible during refuelling operations; however volumes will be minimal due to the mitigation measures proposed.

The mineral sands products have very low to insignificant levels of natural radiation. Spillage of the products into the marine environment is not considered to result in significant impacts to the marine environment and will not result in any discernible changes to the quality of water, sediment or biota in King Sound or adjacent waters.

Sheffield considers that the potential impacts to marine environmental quality will be able to be adequately managed such that the environmental objective for marine environmental quality (Section 9.1) will be met, and that the residual impacts are therefore acceptable.

9.2 AMENITY

The EPA's objective in relation to amenity is "*to ensure that impacts to amenity are reduced as low as reasonably practicable*".

9.2.1 Key Statutory Requirements, Environmental Policy and Guidance

The key legislation relating to managing amenity impacts in Western Australia includes:

- *Environmental Protection Act 1986 (WA)*.
- *Environmental Protection (Noise) Regulations 1997 (WA)*.

In addition to State legislation, the following policy and guidance statements were considered in the impact assessment for amenity:

- A Guideline for Managing the Impacts of Dust and Associated Contaminants from Land Development Sites, Contaminated Sites Remediation and Other Related Activities (DEC 2011).
- EPA Guidance Statement No. 3, Separation Distances between Industrial and Sensitive Land Uses (EPA 2005).
- EPA Guidance Statement No. 13, Consideration of Environmental Impacts from Noise (EPA 2014a).
- Derby Town Planning Scheme No. 5 Amendment No. 5 (SDWK 2001)
- AS4282-1997 Control of the obtrusive effects of outdoor lighting.
- Air Quality and Air Pollution Modelling. Guidance Notes. Perth, Western Australia. (DEC 2006).
- National Environmental Protection (Ambient Air Quality) Measure (2003).
- Western Australian Planning Commission (WAPC) State Planning Policy 5.4 Road and Rail Transport Noise and Freight Considerations in Land Use Planning (WAPC Criteria).
- Implementation Guidelines for State Planning Policy 5.4 (WAPC 2014).

9.2.2 Assessment of Potential Impact

Transport of mineral sands products from the Mine Site through the town of Derby to the Derby Port and loading of product at the Port for export has the potential to impact amenity as a result of noise and dust from truck movements. The following impacts on amenity may occur as a result of road transport of product, construction, and operation of export facilities, and loading of product:

- **Dust emissions causing a decrease in amenity for sensitive receptors.**
- **Noise emissions causing a decrease in amenity for sensitive receptors.**

The Derby Port is an operational port and is zoned for port industrial use under the Derby Town Planning Scheme No. 5 Amendment No. 5 (SDWK 2001). The Derby Port Development Envelope is located approximately 2 km northwest of the Derby townsite, and the two are separated by low mud flats (Figure 38). The majority of the transport route from the Mine Site to the Port has no sensitive receptors due to its remote location, however, sensitive receptors within the town of Derby include residents and businesses located on or near Loch Street (see Section 4.3.3; Figure 38).

9.2.2.1 Dust Emissions Causing a Decrease in Amenity for Sensitive Receptors

There is potential for an increase in airborne dust loadings from activities associated with the project, such as product transport and loading/unloading operations at Derby Port. Airborne particles can cause amenity impacts by settling on surfaces (such as washing hung out to dry, cars, roofs) causing soiling and discolouration (DEC 2011).

The export products have limited potential for dust generation as they are granular, contain few fines and have high specific gravities. Mineral sands products will be unloaded and stored within the Product Storage Facility, which will be negatively pressured to further minimise dust emissions. The site where the Product Storage Facility is to be constructed is already levelled, so minimal disturbance of soils is expected other than for installation of services and foundation works as required.

There will be an average of 20 road train movements (10 return trips) along the transport route per 24 hour period during the operational phase of the project. Other than the Site Access Road within the Mine Site Development Envelope, the transportation route is entirely on sealed roads, vastly decreasing the amount of dust generated when compared to unsealed roads.

Modelled ambient particulate levels as total suspended particles (TSP) and monthly dust deposition for the Derby Port Development Envelope and the transport route (including Derby town centre) are shown in Figure 49 and 50.

Figure 49: Derby Port Maximum Ambient TSP Concentrations, Annual Average (µg/m³)

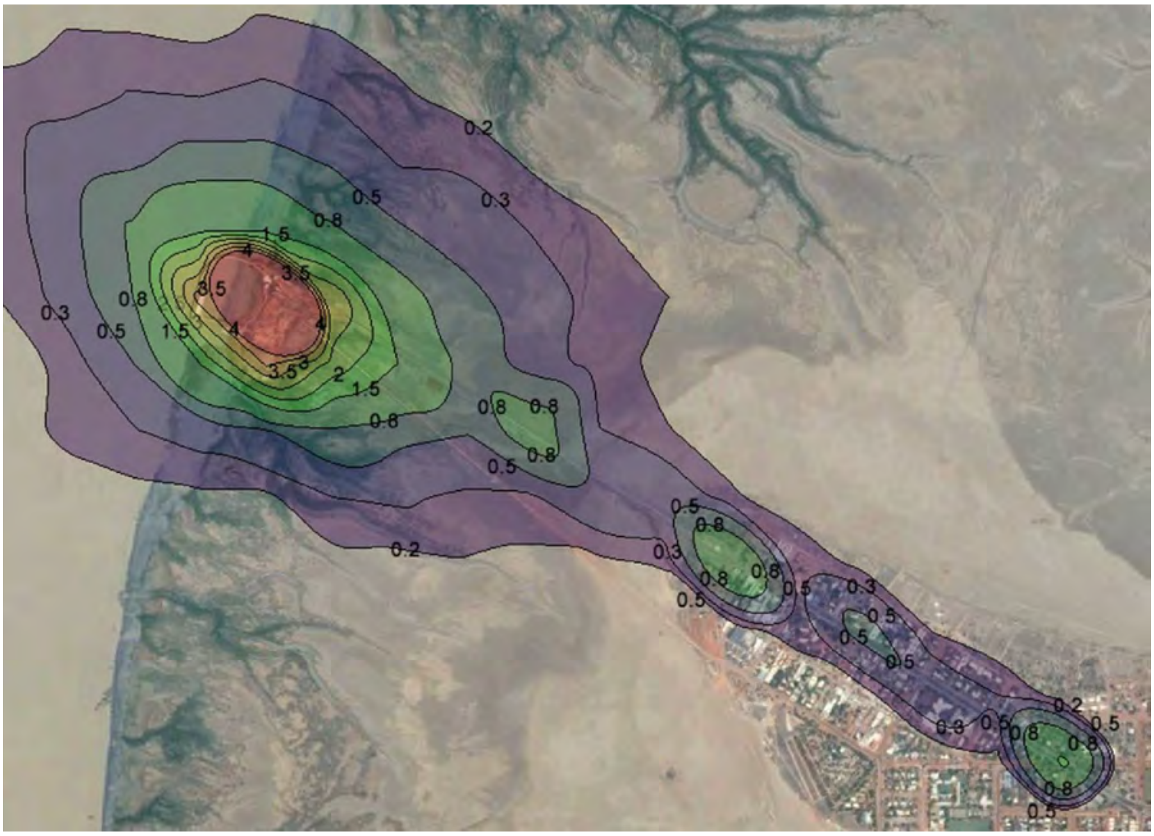


Figure 50: Derby Port Maximum Monthly Dust Deposition Contours (g/m²/month)

Modelling emissions factors were derived from the National Pollutant Inventory Emissions Estimation Handbook for Mining Factors and Mineral Sands. In the absence of specific detailed inputs for the model, the modelling has adopted these standard emissions and is therefore considered conservative. Modelled TSP and dust deposition are below commonly accepted levels based on NSW guidance levels (NSW DEC 2005) n the absence of National Environmental Protection Measures [NEPM] criteria) (Table 66).

Table 66: Modelled Ambient Air Emissions for Port and Transport Activities

Particulate	Unit of Measure	Guideline Limit	Modelled Maximum Project Level		
			Port Boundary	Transport Route	Derby Townsite
Ambient TSP	μg/m³ (annual average)	90[1]	50	41	41
Dust Deposition	g/m²/month	4[2]	3.5	0.8	0.5-0.8

[1] TSP (NSW DEC 2005); [2] Commonly used limit for dust deposition in absence of formal criteria.

As shown in Figure 49, the maximum average ambient TSP concentration in the Derby Port Development Envelope is less than the 90 μg/m³ guideline level, rapidly decreasing to 50 μg/m³ at the Port boundary. No exceedances of the TSP or dust deposition limits are expected at sensitive receptors in the Derby town site. Dust deposition values for the commercial property (café) located north of the proposed Product Storage Facility is on the selected limit (in the absence of any formal criteria). Given that the emissions factors used in the model are considered conservative, it is expected that this value will be within the selected criteria.

Product transport and port activities are 'Likely' to result in only minor, short-term and infrequent loss of amenity along the transport route through the Derby town site and in the Port area. The potential residual impact of dust on amenity of sensitive receptors, after implementation of management measures, is assessed as 'Low'.

Impact	Consequence	Likelihood	Residual Impact
Dust emissions causing a decrease in amenity for sensitive receptors	Incidental	Likely	Low

9.2.2.2 Noise Causing a Decrease in Amenity for Sensitive Receptors

Noise emissions from transport and export operations have the potential to impact the amenity of Derby residents and visitors. Sheffield commissioned a study to quantify existing noise at receptor locations and to predict impacts on those receptors (WSP Parsons Brinkerhoff 2016a; Appendix 18).

The main sources and impacts associated with noise were identified as:

- Decreased amenity for sensitive receptors due to environmental noise caused by operations in the Derby Port Development Envelope.
- Decreased amenity for sensitive receptors due to traffic noise, caused by road train movements through the town of Derby.

Sensitive receptors identified in the study are residences and businesses located along Loch street and Derby Highway, with those most likely to be impacted located closest to the port (i.e. Elder Street, approximately 2 km from the Port; Figure 38). The Jetty Café located in the vicinity of the Port is identified as a receptor however it is not considered sensitive given its commercial nature and location within an established industrial area.

Environmental Noise

The *Environmental Protection (Noise) Regulations 1997* (Noise Regulations) require that noise emitted from any premises must comply with ‘assigned noise levels’ when received at any other premises, and be free of the intrusive characteristics of tonality, modulation and impulsiveness. Assigned levels differ between noise sensitive, commercial and industrial premises, and vary depending on the time of day.

Assigned noise levels for the Derby Port Development Envelope and transport route are presented in Table 67. These are site specific levels developed by WSP (Appendix 18) using measured background noise levels and the methodology provided in the Noise Regulations.

Table 67: Specific Noise Criteria

Time of Day	Receptor	Assigned Level (dB)		
		L_{A10}[1]	L_{A1}[2]	L_{Amax}[3]
Night time Noise Sensitive Premises	Elder Street	40	50	60
Day time Noise Sensitive Premises	Elder Street	50	60	70
Evening Noise Sensitive Premises	Elder Street	45	55	60
Commercial Premises	Jetty Café	60	75	80

[1] *L_{A10} is the noise level exceeded for 10% of the measurement period.*

[2] *L_{A1} is the noise level exceeded for 1% of the measurement period.*

[3] *L_{Amax} is the maximum noise level recorded in the measurement period.*

Environmental noise impacts were modelled at residences in Elder Street and at the Jetty Café. Night time criteria were used for the assessment as these are more stringent and therefore conservative. The noise contour map showing the predicted L_{A10} noise levels from the port operations is shown in Figure 51. The predicted noise levels at the nearest sensitive receiver compared against the relevant (night time) criteria are below specified criteria (Table 68) for the L_{A10} and for the L_{Amax} noise levels.

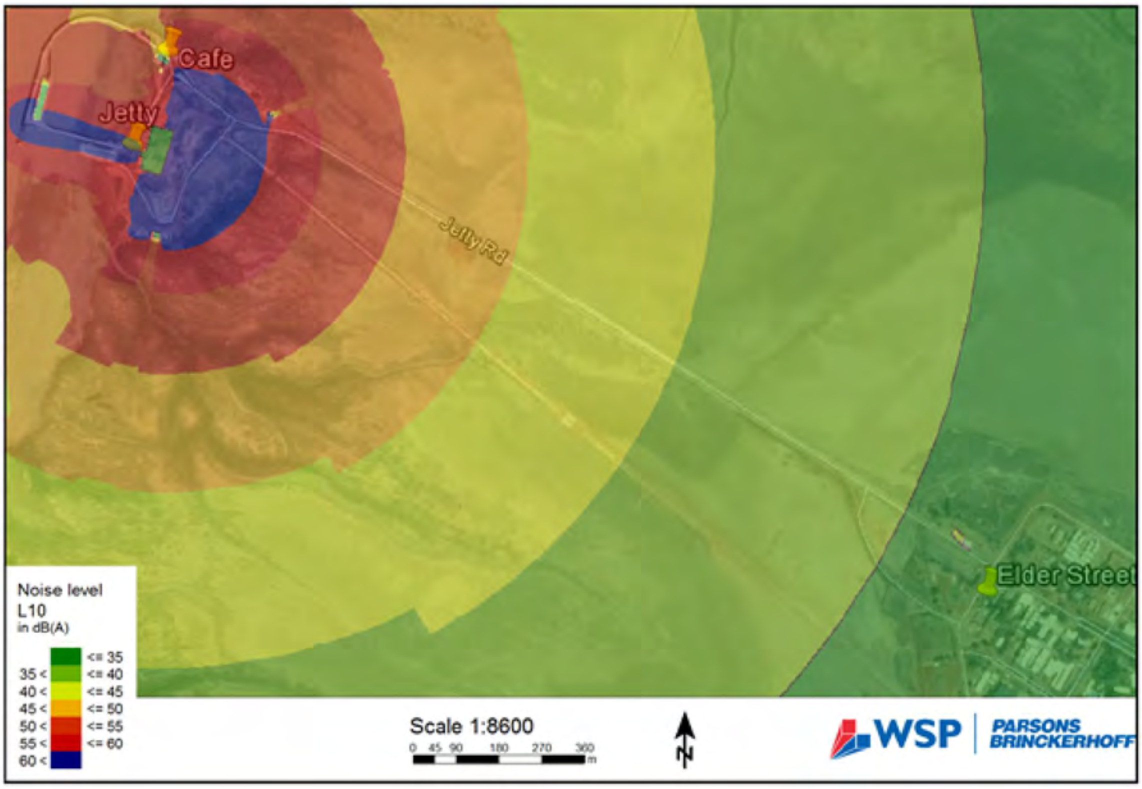


Figure 51: Night Time L_{A10} Noise Contours for Derby Port

Table 68: Assessment of Port Environmental Noise

Receiver	Specific Criteria L_{A10} (dB)[1]	Predicted L_{A10} (dB)[2]	Compliant with Specific Criteria
Port			
Elder Street Residential	40	38	Yes
Jetty Café Commercial	60	58	Yes
Road Trains			
Elder Street Residential	60	38	Yes
Jetty Café Commercial	80	71	Yes

[1] Environmental Protection (Noise) Regulations 1997; [2] With +5 dB tonality adjustment

The predicted noise levels do not exceed the 1 hr $_{LAeq}$ as specified in the Noise Regulations at the identified nearest residential and commercial receivers. The potential residual impact of environmental noise on the amenity of sensitive receptors, after implementation of management measures, is assessed as ‘Low’.

Impact	Consequence	Likelihood	Residual Impact
Environmental noise causing a decrease in amenity for sensitive receptors	Incidental	Likely	Low

Traffic Noise

The most appropriate criteria to assess the impact of road trains on the public roads within the town of Derby is contained within the Western Australian Planning Commission (WAPC) State Planning Policy 5.4 "*Road and Rail Transport Noise and Freight Considerations in Land Use Planning*" (WAPC Criteria, WAPC 2009). This policy sets out the outdoor noise criteria that apply for noise sensitive developments next to road or rail transport corridors. WSP undertook predictive modelling of project related traffic noise (Appendix 18). The predicted traffic noise levels including the additional road train movements as a result of the transport operations compared against the WAPC criteria are shown in Table 69. These levels are based on a modelled 20 return road train movements per day (40 movements total). This is approximately double the volume of road train traffic proposed by Sheffield (refer to Section 3.7) and the assessment is therefore considered highly conservative.

Table 69: Assessment of Traffic Noise Levels

Location	Assessment Period	Existing Noise Level	WAPC Target Criteria	WAPC Limit Criteria	Predicted future* (dB)	Compliant with Limit Criteria
Derby Highway	$L_{Aeq(Day)}$	50.7	55	60	53.5	Yes
	$L_{Aeq(Night)}$	43.4	50	55	48.1	Yes
Loch Street	$L_{Aeq(Day)}$	53.2	55	60	56.1	Yes
	$L_{Aeq(Night)}$	41.2	50	55	48.7	Yes

With +2.5 dB façade correction

The predicted traffic noise levels for receptors along Derby Highway are within the WAPC target criteria for the day and night time periods. The predicted traffic noise levels for receptors along Loch Street are within the WAPC target criteria for the night time period. The predicted day time traffic WAPC noise target is exceeded by 1.1 dB but is within the WAPC limit criteria. Background traffic noise, when façade adjusted to account for noise reflections from nearby buildings, already exceed the WAPC target criteria (WSP Parsons Brinckerhoff 2016).

The predicted increase to current traffic noise as a result of the road train movements on Loch Street and Derby Highway are outlined in Table 70. The increase in overall traffic noise levels as a result of the road trains is negligible during the daytime period. The more significant increases are during the night time period when overall traffic counts are lower, as an increase of up to 3 dB has been predicted. Subjectively, the human reaction to an increase in noise of 3 dB or lower is normally unnoticed to tolerable (WSP Parsons Brinckerhoff 2016a).

Table 70: Predicted Traffic Noise Increase

Location	Assessment Period	Predicted Increase (dB)
Derby Highway	$L_{Aeq(Day)}$	0.3
	$L_{Aeq(Night)}$	2.2
Loch Street	$L_{Aeq(Day)}$	0.4
	$L_{Aeq(Night)}$	3.3

The project related noise emissions are expected to have no adverse amenity impacts on sensitive receptors located in Derby or receptors at the Port. Noise emissions will not exceed the 1 hr L_{Aeq} Noise Guidelines as recommended by the Noise Regulations. The potential residual impact of traffic noise on the amenity of sensitive receptors, after implementation of management measures, is assessed as 'Low'.

Impact	Consequence	Likelihood	Residual Impact
Traffic noise causing a decrease in amenity for sensitive receptors	Incidental	Unlikely	Low

9.2.3 Management Measures

A summary of key measures to address potential impacts on amenity is shown in Table 71.

Table 71: Proposed Management Measures for Protection of Amenity for the Derby Port Development Envelope

Potential Impact Requiring Management	Measure
Dust emissions causing a decrease in amenity for sensitive receptors	• Bulk products will be transported to the Derby Port Development Envelope in covered containers. • Bulk product will be stored in a purpose built Product Storage Facility. This will include a drive through enclosed unloading area to ensure product is contained. • Transfer of product to barges will be via a covered conveyor. • Spillages of product on land will be cleaned up as required. Spilt product will either be returned to the Product Storage Facility or returned to the Mine Site for reprocessing or disposal.
Noise emissions causing a decrease in amenity for sensitive receptors	• Road trains will be maintained in good mechanical condition to minimise noise associated with their operation. • The use of engine brakes within the built-up area of Derby will only be permitted for emergency breaking. • Road train speed limits through the town of Derby will be determined in consultation with the Shire of Derby/West Kimberley, Main Roads WA and other stakeholders. • Sheffield will develop and implement a community feedback and complaints mechanism.

9.2.4 Predicted Outcome

Derby Port is currently a functioning industrial site within a zoned industrial area.

Ambient concentrations for dust at the Port boundary and along the transport route will be within accepted limits and will not impact on sensitive receptors in Derby.

Modelled noise levels as a result of the project are below DER 1 hr L_{Aeq} noise limits as defined in the *Environmental Protection (Noise) Regulations 1997* for receptors.

Noise impacts on sensitive receptors in the town of Derby are unlikely to cause loss of amenity for Derby residents and Port users.

Sheffield considers that the potential impacts to amenity will be able to be adequately managed such that the environmental objective (Section 9.2) for amenity will be met, and that the residual impacts are therefore acceptable.

10. ENVIRONMENTAL IMPACT ASSESSMENT - OTHER ENVIRONMENTAL FACTORS - MINE SITE DEVELOPMENT ENVELOPE

Other relevant environmental factors for the Mine Site Development Envelope comprise the following:

- Landforms.
- Subterranean Fauna.
- Terrestrial Environmental Quality.
- Air Quality and Atmospheric Gases.
- Human Health.

Potential impacts for each factor are detailed in Sections 10.1 to 10.5.

10.1 LANDFORMS

The EPA's objective for landforms is "*to maintain the variety, integrity, ecological functions and environmental values of landforms*".

10.1.1 Key Statutory Requirements, Environmental Policy and Guidance

The key legislation relating to managing impacts on landforms in Western Australia includes:

- *Environmental Protection Act 1986* (WA).

In addition to State legislation, the following policy and guidance statements were considered in the impact assessment for landforms:

- Environmental Assessment Guideline 8, Environmental Assessment Guideline for Environmental Principles, Factors and Objectives (EPA 2015c).
- Environmental Protection Bulletin No. 23, Guidance on the EPA Landforms Factor (EPA 2015g).

10.1.2 Assessment of Potential Impact

The EPA defines landform as a 'distinctive, recognisable physical feature on the earth's surface having a characteristic shape produced by natural processes' (EPA 2015g).

From a review of regional contours surrounding the Mine Site Development Envelope (up to 30 km away), it is clear that the most distinctive landforms in relation to the Mine Site are a northwest to southeast trending band of low hills parallel to the Mine Site Development Envelope associated with the Reeves Land System. The distinctive landform features within the band are Reeves Hill, Dampier Hill, Mt Jowlaenga and several unnamed smaller hills to the east and north of the Mine Site Development Envelope (Figure 21). None of these landforms will be impacted by the project.

The only two constructed landforms remaining at closure of the project will comprise the mineral deposit area and the initial TSF. The mineral deposit area will be progressively backfilled and rehabilitated and will not be significantly distinguishable from the surrounding area. Potential impacts associated with these two constructed landforms include:

- **Post-mining landforms are inconsistent with the surroundings.**
- **Post-mining landforms are unstable.**

The assessed likelihood, consequence and residual impact (as per Section 7.3), is provided below for each potential impact.

10.1.2.1 Post-mining Landforms Inconsistent with Surroundings

The mining process will change the detail of the flat, evenly sloping profile of the current site, creating shallow sloping raised areas and depressions. These minor amendments to the relative levels are consistent with rehabilitation practices at other mineral sands mines and are not expected to result in landforms that are inconsistent with their surroundings.

The initial TSF surface at the end of mine life will potentially be elevated in excess of 10 m above the surrounding landscape and hence will be more pronounced. This will be shaped and rehabilitated to match surrounding landforms as outlined in the preliminary MCP (Appendix 4) and as detailed in subsequent revisions of the MCP.

The mining process and initial TSF are ‘Unlikely’ to result post-mining landforms that are inconsistent with their surroundings. The potential residual impact, after implementation of management measures, is assessed as ‘Low’.

Impact	Consequence	Likelihood	Residual Impact
Post-mining landforms are inconsistent with surroundings.	Minor	Unlikely	Low

10.1.2.2 Post-mining Landforms are Unstable

Materials characterisation work has been completed on soils and mine waste, including overburden and process residues (Appendix 6, Appendix 19 and Appendix 20). This work determined that overburden material, including the local Pindan soils, has a low coherence and limited wet strength and is not favourable for rehabilitation of steeply sloping surfaces. However, the material is well suited for rehabilitation of flat or gently sloping surfaces such as expected within the mineral deposit area or the initial TSF surface. The only potential requirement to rehabilitate steeply sloping surfaces is on the embankments of the initial TSF. Pindan soil blended with ferruginous sandstone overburden is expected to provide a suitable cover for these areas that will not excessively erode or result in instability.

Post-mining landforms are considered ‘Unlikely’ to be unstable with only ‘Minor’ erosion expected. The potential residual impact, after implementation of management measures, is assessed as ‘Low’.

Impact	Consequence	Likelihood	Residual Impact
Post-mining landforms are Unstable.	Minor	Unlikely	Low

10.1.3 Management Measures

Management measures for constructed landforms are detailed in the preliminary MCP (Appendix 4).

10.1.4 Predicted Outcome

Due to the lack of impact on existing landforms from project activities, and the predicted low impact of constructed landforms, Sheffield considers that the environmental objective (Section 10.1) for landforms will be met.

10.2 SUBTERRANEAN FAUNA

The EPA's objective in relation to subterranean fauna is "*to maintain representation, diversity, viability and ecological function at the species, population and assemblage level*".

10.2.1 Key Statutory Requirements, Environmental Policy and Guidance

Subterranean fauna are protected under Commonwealth and State legislation, governed by three Acts:

- *Wildlife Conservation Act 1950* (WA).
- *Environmental Protection Act 1986* (WA).
- *Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth).

In addition to State legislation, the following policy and guidance statements were considered in undertaking fauna surveys and in the impact assessment for subterranean fauna:

- Environmental Assessment Guideline 12, Consideration of Subterranean Fauna in Environmental Impact Assessment in Western Australia (EPA 2013a).
- EPA Guidance Statement 54a, Sampling Methods and Survey Considerations for Subterranean Fauna in Western Australia (EPA 2007).

10.2.2 Assessment of Potential Impact

Despite widespread sampling during the pilot survey within the Mine Site Development Envelope, no stygofauna were recorded. This together with the absence of previous records of stygofauna on the Dampier Peninsula indicates that it is unlikely that a significant or diverse stygofaunal assemblage exists within the Mine Site Development Envelope.

The majority of the Mine Site Development Envelope provides little to no habitat for troglofauna and is comprised almost solely of sands above the water table. This is supported by the fact that only a single specimen was recorded from within the Mine Site Development Envelope while a second specimen was recorded in the sandstone ranges to the east of the Mine Site Development Envelope, despite five drill holes containing rock strata being sampled. Given the fact that this taxon was recorded within the sandstone strata, which continues extensively to the east and north of the Mine Site Development Envelope, its distribution is unlikely to be confined to the Mine Site Development Envelope.

10.2.3 Management Measures

No management measures are required for subterranean fauna.

10.2.4 Predicted Outcome

Due to the lack of subterranean fauna being recorded within the Mine Site Development Envelope and immediate surroundings, the project will not result in loss to the representation, diversity, viability or ecological function of subterranean fauna species, population and assemblages. Sheffield considers that the environmental objective for subterranean fauna (Section 10.2) will be met.

10.3 TERRESTRIAL ENVIRONMENTAL QUALITY

The EPA's objective in relation to terrestrial environmental quality is "*to maintain the quality of land and soils so that the environment values, both ecological and social, are protected*".

10.3.1 Key Statutory Requirements, Environmental Policy and Guidance

Terrestrial environmental quality is protected under Commonwealth and State legislation, governed by the following Acts:

- *Dangerous Goods Safety Act 2004* and associated regulations (WA).
- *Contaminated Sites Act 2003* and associated regulations (WA).
- *Environmental Protection (Unauthorised Discharges) Regulations 2004* (WA).
- *Environmental Protection (Rural Landfill) Regulations 2002 (WA)*.
- *Environmental Protection (Controlled Waste) Regulations 2004 (WA)*.
- *Mining Act 1978* and associated regulations (WA).
- *Mines Safety and Inspection Act 1994* and Regulations 1995 (WA).

In addition to State legislation, the following policy and guidance statements were considered in the impact assessment for terrestrial environmental quality:

- Guidelines for Preparing Mine Closure Plans (DMP and EPA 2015).
- Principles of the Strategic Framework for Mine Closure (ANZMEC and MCA 2000).
- Guide to Departmental Requirements for the Management and Closure of Tailings Storage Facilities (DMP 2015).
- Guidance for the Assessment of Environmental Factors 6, Rehabilitation of Terrestrial Ecosystem (EPA 2006a).
- Guideline on Investigation Levels for Soil and Groundwater. Schedule B1. (NEPC 2013)

10.3.2 Assessment of Potential Impact

Potential impacts to terrestrial environmental quality in the Mine Site Development Envelope are:

- **Erosion and sedimentation causing loss of topsoil.**
- **Erosion and sedimentation causing loss of soil material from disturbed areas**.
- **Disposal of mine and processing wastes causing contamination of the environment** – disposal within the initial Tailings Storage Facility (TSF) and as backfill within the mining excavation leading to contamination of the environment.
- **Accidental spills and leaks causing contamination of the environment** – spills or leaks of hydrocarbons and process reagents leading to contamination of the environment.
- **Discharge of inadequately treated sewage effluent causing contamination of the environment**.
- **Poorly designed and operated landfill causing contamination of the environment.**

The assessed likelihood, consequence and residual impact (as per Section 7.3), is provided below for each potential impact.

10.3.2.1 Erosion and Sedimentation Causing Loss of Topsoil

Topsoil will initially be stockpiled for use in rehabilitation and revegetation and then direct replaced as part of progressive rehabilitation activities. Inappropriate removal and stockpiling methods can result in a reduction in soil quality and structure, as well as affecting the viability of the seed bank within the topsoil. In order to prevent this from happening, Sheffield will ensure that topsoil is not handled when wet to avoid damaging soil structure and composition. Topsoil when requiring storage, will be stored in low stockpiles no higher than 2 m to retain the viability of seeds and prevent erosion from affecting the stockpiles. The duration that topsoil is stockpiled will be minimised as far as practicable, and where possible, will be returned directly to mined areas that are ready to be rehabilitated. All topsoil stockpiles will be located away or protected from stormwater flows, minimising potential losses via erosion and sedimentation.

Some minor topsoil loss is 'Likely' to occur over the life of the project; however this is not expected to cause any noticeable impacts on associated environmental values within the Mine Site Development Envelope. The potential residual impact of erosions and sedimentation on topsoil, after implementation of management measures, is assessed as 'Low'.

Impact	Consequence	Likelihood	Residual Impact
Erosion and sedimentation causing loss of topsoil	Incidental	Likely	Low

10.3.2.2 Erosion and Sedimentation Causing Loss of Soil Material from Disturbed Areas

The natural land surface within the Mine Site Development Envelope will be disturbed by construction of infrastructure and progressive mining within the mineral deposit area. This may result in erosion of soil materials and subsequent transfer of sediment downstream.

Drainage in the Mine Site area typically occurs as low energy sheet flow due to the low gradient. Some concentrated streams are expected around infrastructure areas such as the ore processing plant and Initial TSF and these may cause minor and very localised erosion if inappropriately managed. Sheffield proposes to use a series of sediment traps in these locations to reduce flow energy and remove sediment from stormwater.

Rehabilitation is planned for all disturbed surfaces with the initial TSF being the only remaining permanent landform. Soil profiles will be reinstated as the mining excavation is progressively backfilled and rehabilitated with mine wastes, overburden, process residues and topsoil. Revegetation of disturbed surfaces with native species will provide stability to disturbed soils and will minimise erosion and sedimentation processes. Rehabilitation and Closure is discussed further in Section 12.

Some minor, localised soil loss is considered 'Likely' to occur over the life of mine within disturbed areas; however the consequence on associated environmental values within the Mine Site Development Envelope is considered to be 'Incidental'. This impact is therefore assessed as 'Low'.

Impact	Consequence	Likelihood	Residual Impact
Erosion and sedimentation causing loss of soil material from disturbed areas	Incidental	Minor	Low

10.3.2.3 Mining and Disposal of Mine and Processing Wastes Causing Contamination of the Environment

Impacts from mining and disposal of mine and processing wastes causing contamination of the terrestrial environment are considered in Section 8.4.2.3 Inland Water Quality. However, impacts to soil are considered to be less than those to water quality as Potentially Acid Forming (PAF) material found at a depth does not form part of the ore body and will not be mined by Sheffield, so should not result in excavation and potential placement of this material at the surface.

Based on the assessment results as presented in Section 8.4.2.3 Inland Water Quality, it is considered 'Unlikely' that mining activities will result in any exceedances of soil quality guidelines at any sensitive receptors within or adjacent to the Mine Site Development Envelope with an impact consequence of 'Minor' for the vast majority of waste overburden/soil/mixed residues streams. The potential impact from mining and mine and process wastes disposal on the terrestrial soil quality, after implementation of management measures, is assessed as 'Low'.

Impact	Consequence	Likelihood	Residual Impact
Disposal of mine and processing wastes causing contamination of the environment	Minor	Unlikely	Low

10.3.2.4 Accidental Spills and Leaks Causing Contamination of the Environment

Impacts from accidental spills and leads causing contamination of the terrestrial environment are considered the same as those for Inland Water Quality as discussed in Section 8.4.2.2.

10.3.2.5 Discharge of Inadequately Treated Sewage Effluent Causing Contamination of the Environment

Impacts from discharge of inadequately treated sewage effluent causing contamination of the terrestrial environment are considered the same as those for Inland Water Quality as discussed in Section 8.4.2.3.

10.3.2.6 Poorly Designed and Operated Landfill Causing Contamination of the Environment

Impacts from poorly designed and operated landfill causing contamination of the terrestrial environment are considered the same as those for Inland Water Quality as discussed in Section 8.4.2.3.

10.3.3 Management Measures

A summary of key measures to address potential impacts on Terrestrial Environmental Quality is shown in Table 72. No further specific management measures for terrestrial environmental quality are required as management measures detailed in Section 8.1.2 for flora and vegetation, Section 8.4.3 inland water quality and Section 12 rehabilitation and decommissioning adequately mitigate impacts to terrestrial environmental quality.

Table 72: Proposed Management Measures for Protection of Terrestrial Environmental Quality for the Mine Site Development Envelope

Potential Impact Requiring Management	Measure
Dust generation or product spillage	• Dust will be managed by watering unsealed roads with a water cart or with fixed sprays as required. • Vehicle traffic will be confined to defined roads and tracks. • During high winds, topsoil and overburden stripping and spreading activities will be restricted if dust cannot be adequately controlled. • Vehicles will be required to travel at safe operating speeds on unsealed roads and will be restricted from accessing rehabilitated surfaces except for management purposes. • Spilt ore and materials outside of the ore processing areas will be regularly cleaned up. • Bulk products will be transported in covered containers.
Radiation exposure affecting terrestrial environment	• Rehabilitated areas will be monitored to ensure radiation levels are within environmental screening criteria (10 µGy/h) or established pre-mining background levels.

10.3.4 Predicted Outcome

There will be no permanent disturbance aside from a small TSF which represents 106 ha of disturbance on completion as the mining excavation will be backfilled and rehabilitated. Mine wastes are expected to be benign apart from sulfidic material measured at extreme depth, with monitoring and management measures to be developed and implemented before this material is disturbed.

Sheffield considers that the potential impacts on terrestrial environmental quality will be able to be adequately managed such that the objective (Section 10.3) will be met, and that the residual impacts are therefore acceptable.

10.4 AIR QUALITY AND ATMOSPHERIC GASES

The EPA's objective in relation to air quality is "*to maintain air quality for the protection of the environment and human health and amenity, and to minimise the emission of greenhouse and other atmospheric gases through the application of best practice*".

10.4.1 Key Statutory Requirements, Environmental Policy and Guidance

The key legislation relating to managing impacts on landforms in Western Australia includes:

- *National Environmental Protection (Ambient Air Quality) Measure 2003* (WA).

In addition to State legislation, the following policy and guidance statements were considered in the impact assessment for air quality and atmospheric gases:

- Air Quality Modelling Guidance Notes. Perth, WA. (DEC 2006).
- A Guideline for Managing the Impacts of Dust and Associated Contaminants from Land Development Sites, Contaminated Sites Remediation and Other Related Activities (DEC 2011).
- EPA Guidance Statement No. 3, Separation Distances Between Industrial and Sensitive Land Uses (EPA 2005).
- Environmental Protection Bulletin Number 24, Greenhouse Gas Emissions and Consideration of Projected Climate Change Impacts in the EIA Process (EPA 2015h).
- *National Environment Protection Measure for Ambient Air Quality 1994* as Amended 2003 (NEPC 2003).

10.4.2 Assessment of Potential Impact

Activities to be conducted at the Mine Site Development Envelope, including mining, processing, handling and transport of mined material, as well as onsite power generation and process heat requirements, have the potential to impact on air quality through emissions of dust and combustion products. The following impacts may occur:

- **Dust emissions affecting air quality** from:
  - Mining activities (e.g. clearing, vehicle movements).
  - Fixed stacks associated with the secondary processing plant.
  - Handling and transport of mined material, process material and final product.
  - Stored mine wastes (Tailings Storage Facility [TSF] and mine excavation backfill).

Combustion emissions from onsite power generation, process heating requirements, and vehicles and equipment can affect air quality.

- **Combustion emissions affecting air quality**:
  - Oxides of nitrogen.
  - Carbon monoxide.
  - Sulfur dioxide.
  - Greenhouse gas emissions.

Other potential impacts were screened out from further assessment (Section 7.4) as they were either assessed as not likely to occur or were unlikely to have any discernible consequence on any factor different to background levels:

Stressor	Justification for Exclusion
Odour emissions affecting air quality	A purpose built landfill facility will be constructed at the Mine Site for disposal of putrescible wastes. These will be covered with at least 200 mm of inert material about once a week. Sewage will be treated to an acceptable standard via package WWTP located in the accommodation village and ore processing are before disposal of effluent and solids. Odour emissions from processing (in particular roasting) are expected to be minor and rapidly dispersed by use of an elevated stack as for other gaseous emissions which were modelled. Odours from these sources will be minimised by correct operation of the facilities. Any odour emissions will be localised and are not expected to affect air quality for employees who are the closest sensitive receptors.

The assessed likelihood, consequence and residual impact (as per Section 7.3), is provided below for each potential impact.

10.4.2.1 Dust Emissions Affecting Air Quality

Airborne particulate matter produced from construction and mine activities can potentially reduce air quality, and be inhaled. Particles of size greater than 10 microns aerodynamic diameter (PM_{10}) are considered to represent an amenity issue rather than a health issue as they adhere to and are screened out in the upper respiratory tract. Particles less than PM_{10}, and specifically those less than 2.5 microns ($PM_{2.5}$) are strongly linked to adverse human health effects such as cardiovascular disease and respiratory effects (NEPC 2014).

Dust impacts from the Mine Site Development Envelope were assessed using predictive modelling undertaken by Atmospheric Solutions (Appendix 12), with results compared to National Environmental Protection Measures (NEPM) Ambient Air Quality (AAQ) standards.

Modelling indicates that airborne particulates (TSP, PM_{10} and $PM_{2.5}$) and deposited dust levels are 'likely' to be elevated in localised areas within the immediate vicinity of the sources of emissions, i.e. the Mine Site and Site Access Road. However, these levels quickly fall below the standard within a short distance. It is important to note that the NEPM reference air quality criteria for PM_{10} and $PM_{2.5}$ are intended for application within the ambient air environment of residential areas, not at the lease boundary of industrial point source emissions. Given the lack of such receptors, there is not expected to be any adverse air quality impacts.

The accommodation village is located 4 km from the Mine Site, and is predicted to experience air quality well within the criteria – only $PM_{2.5}$ being increased marginally above ambient background levels.

Impacts of deposited dust on vegetation immediately adjacent to the Site Access Road and mining activity is discussed in Section 8.1.

Standard processes and procedures will be implemented during operation of the project to minimise dust emission, such as; vehicles and mining equipment will keeping to designated roads, progressive clearing kept to a minimum requirement at any one time, progressive rehabilitation and dust suppression. Positional dust monitoring will be undertaken as required for the radiation management plan and environmental management plan at suitable locations around the Mine Site Development Envelope such as a suitable distance from the active void area and boundary locations.

Based on the modelling results, mining activities are predicted to ‘Rarely’ result in any exceedances of the NEPM AAQ standards at any sensitive receptors within or adjacent to the Mine Site Development Envelope. The residual impact from dust emissions on air quality, after implementation of management measures, is assessed as ‘Low’.

Impact	Consequence	Likelihood	Residual Impact
Dust emissions affecting air quality	Incidental	Rare	Low

10.4.2.2 Combustion Emissions Affecting Air Quality

Combustion emissions produced from activities within the Mine Site Development Envelope that may reduce air quality are oxides of nitrogen, carbon monoxide, sulfur dioxide and greenhouse gas (carbon dioxide) emissions.

Measures to reduce combustion emissions are considered to be universal for all species emitted, such as regular preventative and, where needed, corrective maintenance on vehicles and plant and use of Euro V standard vehicles and equipment (post 2009) or appropriate quality diesel fuel will be used to lower NOx and particulate emissions. Additionally, where appropriate, options for reduction in greenhouse gas emissions and/or carbon offsets will be investigated during the project life.

Oxides of Nitrogen Affecting Air Quality

Oxides of nitrogen (NO_X) include nitric oxide (NO), a colourless gas with a sharp, sweet odour, and nitrogen dioxide (NO_2), a dark brown gas with a pungent, acrid odour. Both NO and NO_2 can reduce visibility, with NO_X contributing significantly to haze as well as to regional air pollution as a precursor to photochemical pollution. NO_X is also a factor in the formation of acid rain. Elevated levels of NO_X, particularly NO_2, can cause a variety of impacts including damage to plant tissues and the increased acidity of rain (i.e. lower pH) which can in turn, lower soil, surface water, and groundwater pH, potentially having harmful secondary effects. In humans, exposure to elevated NO_2 levels can result in a number of health impacts.

NO_X are produced by the combustion of fuel in the presence of nitrogen, however approximately 95% of NO_X present in exhaust gas is NO, with the remaining 5% NO_2 (sometimes called ‘thermal NO_2’). On release, NO reacts with available ozone (O_3) to form NO_2, increasing the ratio of NO_2 to NO. Subsequently, NO_2 breaks down in the presence of sunlight to form NO and O_3. It is this (highly simplified) series of reactions that contributes to photochemical smog, a significant problem in populated cities. The ambient air quality limit for environmental health exposure for NO_2 in the NEPM AAQ is 0.12 ppm, or 246 µg/m^3, on an hourly average (NEPC 2003).

In the project location, there will be limited background O_3 levels to allow for significant NO_2 generation. Modelling by Atmospheric Solutions (2016, Appendix 12), indicates that predicted NO_2 levels are highest in the immediate vicinity of the power station and mineral separation plant with maximum hourly average levels of approximately 30 µg/m^3 which is significantly below the NEPM AAQ criteria of 246 µg/m^3. No observable increase in concentration is predicted at the accommodation village. Newer fuel standards including Euro V (DIRD 2016) have lowered NO_X emissions by 17% versus previous 2004 standards in diesel vehicles and will be adopted to lower NO_X as much as practicable.

Based on the modelling results, power generation and processing activities 'Rarely' result in any exceedances of the NEPM AAQ standards for NOx at any sensitive receptors within or adjacent to the Mine Site Development Envelope. The potential residual impact from oxides of nitrogen on air quality, after implementation of management measures, is assessed as 'Low'.

Impact	Consequence	Likelihood	Residual Impact
Oxides of nitrogen affecting air quality	Incidental	Rare	Low

Carbon Monoxide Affecting Air Quality

Carbon monoxide (CO) is an odourless, colourless gas produced via natural sources such as the oxidation of methane, and from the incomplete combustion of fossil fuels. CO is eventually converted to carbon dioxide in the atmosphere, or through the action of soil micro-organisms and plants. CO prevents the absorption and transport of oxygen in the blood by combining with haemoglobin to produce carboxy-haemoglobin. As such, CO is toxic at high concentrations, and exposure can be fatal. Chronic exposure to mild or moderate (occupational) levels of CO can lead to a number of health disorders (ATSDR 2012).

The ambient air quality limit for environmental health exposure for 8 hourly averaged CO in the NEPM AAQ is 9.0 ppm, or 10,300 µg/m^3 (NEPC 2003). Modelling by Atmospheric Solutions (Appendix 12) has indicated maximum 8 hourly CO levels in the vicinity of the power station and processing plant of approximately 20 µg/m^3 due to relatively low levels of combustion emissions. No observable increase in concentration is predicted at the proposed accommodation village.

Based on the modelling results, power generation and processing activities will 'Rarely' result in any exceedances of the NEPM AAQ standards for CO at any sensitive receptors within or adjacent to the Mine Site Development Envelope. The potential residual impact of carbon monoxide on air quality, after implementation of management measures, is assessed as 'Low'.

Impact	Consequence	Likelihood	Residual Impact
Carbon monoxide affecting Air quality	Incidental	Rare	Low

Sulphur Dioxide Affecting Air Quality

Sulphur dioxide (SO_2) is the most abundant sulphur-containing compound in the atmosphere generated from man-made sources. The main contributor globally is the burning of coal, with considerable contributions also from petroleum combustion (diesel fuel) and smelting.

SO_2 in the atmosphere is eventually oxidised to sulphur trioxide (SO_3) which combines with water (H_2O) to form sulphuric acid (H_2SO_4). H_2SO_4 is removed from the atmosphere by rainfall (and to a lesser extent by adsorption to particulate matter and particulate deposition) and therefore is the main component of acid rain. Acid rain has a critical effect on human, animal and plant health, with acidic deposits adversely affecting both land and water ecosystems. Human exposure to low concentrations of SO_2 can cause irritation of the eyes, nose and throat, choking and coughing. Repeated or prolonged exposure to moderate concentrations may cause inflammation of the respiratory tract, wheezing and lung damage. It has also been proved to be harmful to the reproductive systems of animals and caused developmental changes in their newborn.

The ambient air quality limit for environmental health exposure for SO_2 as an hourly average in the NEPM AAQ is 0.2 ppm, or 570 µg/m^3 (NEPC 2003). Modelled SO_2 levels were found to be very low with maximum modelled concentrations of 0.25 to 0.3 µg/m^3 (Appendix 12).

Based on the modelling results, mining and processing activities will 'Rarely' result in any exceedances of the NEPM AAQ standards for SO_2 at any sensitive receptors within or adjacent to the Mine Site Development

Envelope. The potential residual impact of sulphur dioxide on air quality, after implementation of management measures, is assessed as 'Low'.

Impact	Consequence	Likelihood	Residual Impact
Sulfur dioxide affecting air quality	Incidental	Rare	Low

Greenhouse Gas Emissions Affecting Air Quality

Greenhouse gas emissions (mostly as carbon dioxide) will primarily be produced from power generation and transport fuel requirements including transport of product for export. Use of compressed gases (e.g. welding) in workshops etc. and onsite waste management/landfill are considered to be comparatively small in comparison to the above sources and have been excluded from emissions calculations. Land clearing conducted progressively throughout the project will be offset by re-vegetation and is considered carbon neutral overall. Table 73 summarises the estimated projected greenhouse gas emissions from diesel consumption (dozers, excavators, trucks, watercarts, graders and light vehicles) and gas consumption (power generation, roasting and other processing requirements) across the two mining stages (Section 1.2.1) and for the total life of the project.

Table 73: Average Annual and Total Life of Mine Estimated Greenhouse Gas Emissions*

Source	Unit	Quantity	Emissions (t CO_2-e)	Percentage of Total
Stage I				
Total Diesel Fleet	kL/annum	4,431	12,060	9.8
Power Generation	GJ/annum	1,040,996	53,642	43.5
Roaster	GJ/annum	552,672	28,479	23.1
Other Processing	GJ/annum	566,352	29,184	23.7
		Stage I Total (5 years)	**123,365**	**100%**
Stage II				
Total Diesel Fleet	kL/annum	7,032	19,139	7.6
Power Generation	GJ/annum	2,278,125	117,392	46.6
Roaster	GJ/annum	1,105,344	56,958	22.6
Other Processing	GJ/annum	1,132,704	58,368	23.2
		Stage II Total (42 years)	**251,857**	**100%**
Total Life of Project				
Total Diesel Fleet	kL	331,563	902,410	8.0
Power Generation	GJ	100,886,230	5,198,667	46.3
Roaster	GJ	49,187,808	2,534,648	22.6
Other Processing	GJ	50,405,328	2,597,387	23.1
		Grand Total (47 years)	**11,233,112**	**100%**

** Stage I calculated based on 7.5 Mtpa processing rate finishing in year 5, Stage II 15 Mtpa processing years 6 to 47.*

Results provided in Table 73 are considered an upper estimate as they assume maximum energy consumption at all times over the life of the project and are based on 2004 diesel specifications. For comparative purposes, predicted carbon dioxide emissions for the project have been compared to the corporate reporting figures of Iluka Resources for the 2014/15 reporting period (Iluka 2014), as published by National Greenhouse and Energy Reporting:

- Iluka Resources 900,200 t of product for National Greenhouse and Energy Reporting reported 255,006 t CO_2-e (0.28 t CO_2/t product).
- Sheffield Stage II 644,000 t of product for calculated 251,857 t CO_2-e (0.39 t CO_2/t product).

Given the conservative assessment used to derive the project CO_2 emissions, the project emissions are considered comparable to those reported by Iluka Resources for similar production – allowing for a deeper ore resource at the Thunderbird deposit in comparison to generally shallow Iluka deposits.

Additional minor contributions are anticipated from travel of site personnel, waste removal from site, and site deliveries by external contractors. These processes are considered to be under the operational control of contractors and have been excluded from this assessment. Based on projected mining and processing activities, it is considered 'Almost Certain' to result in net CO_2 emissions, however the consequence of these to the state is considered 'Minor'. The potential residual impact of greenhouse gas emissions on air quality, after implementation of management measures, is assessed as 'Medium'.

Impact	Consequence	Likelihood	Residual Impact
Greenhouse gas emissions affecting air quality	Minor	Almost Certain	Medium

10.4.3 Management Measures

A summary of key measures to address potential impacts on air quality is shown in Table 74. No further management measures are considered necessary.

Table 74: Proposed Management Measures for Air Quality for the Mine Site Development Envelope

Potential Impact Requiring Management	Measure
Dust emissions affecting air quality	• During high winds, topsoil stripping and spreading activities will be restricted if dust cannot be adequately controlled. • Vehicles and mining equipment will keep to designated roads. • Vehicles will be required to travel at safe operating speeds on unsealed roads and will be restricted from accessing rehabilitated surfaces except for management purposes. • Clearing will be undertaken progressively and kept to the minimum requirement. • Progressive rehabilitation will be undertaken on disturbed areas as they become available. • Dust suppression will be carried out during construction, operation and closure. • Sheffield will maintain equipment in accordance with manufacturers' specifications to minimise particulate and gaseous emissions.
Combustion emissions affecting air quality	• Vehicles and plant will undergo regular preventative maintenance and, as needed, corrective maintenance. • Euro V standard vehicles and equipment (post 2009) or appropriate quality diesel fuel will be used to minimise NOx and particulate emissions. • Energy efficiency has been considered in the selection and design of equipment and plant. • Sheffield will specify preference for use of low emission producing equipment in equipment supply contracts.

10.4.4 Predicted Outcome

The results of modelling indicate that all pollutants, both dust (TSP, PM_{10}, $PM_{2.5}$ and dust deposition) and combustion products (NO_X, CO, SO_2), will be well within the assessment levels at appropriate distances from the activity and nearby receptors such as the accommodation village. No residential receptors outside the Mine Site Development Envelope will be impacted by pollutants.

Potential air quality impacts from the project may occur as a result of dust generated by the construction, mining, processing, handling and transport of the mined material, as well as low levels of gaseous combustion emissions from onsite power generation and process heat requirements. Dust generation is the primary contributor to potential air quality impacts for the project, however use of dust suppression along the Site Access Road around the Mine Site will adequately control dust emissions.

The air quality impacts of the Mine Site Development Envelope and unsealed access road are not expected to result in any adverse air quality impacts in the region (Appendix 12).

Sheffield considers that the potential impacts to air quality will be able to be adequately managed such that the environmental objective (Section 10.4) for air quality will be met, and that the residual impacts are therefore acceptable.

10.5 HUMAN HEALTH

The EPA's objective in relation to human health is "*to ensure that human health is not adversely affected*".

10.5.1 Key Statutory Requirements, Environmental Policy and Guidance

The key legislation relating to managing human health in Western Australia includes:

- *Radiation Safety Act 1975* (WA).
- *Radiation Safety (Transport of Radioactive Substances) Regulations 2012 (WA)*.
- *Mines Safety and Inspection Regulations 1995* (WA).

10.5.2 Assessment of Potential Impact

This section discusses the radiological environment in relation to the project, in particular the potential impact of the Mine Site operations on potential worker and public exposures. Assessment of potential for human health impacts from respirable dust and combustion emissions is discussed in Section 10.4.

Naturally occurring radioactive materials (NORMs) contain the elements thorium and uranium which are associated with heavy minerals, and in particular with monazite. As demonstrated in the mine residues characterisation (MBS 2016, Appendix 20) the uranium and thorium in monazite is tightly bound and unavailable environmentally, but is still subject to radioactive decay and emissions proportional to the concentration of monazite. Ore, waste and product materials generated by the mining and processing of heavy mineral sands on site has the potential to impact on human health by exposure to radiation. As the Mine Site will generate significant quantities of product and various waste materials for return to the mining void, these materials will be classed and regulated as radioactive substances under the *RS Act*. A Radiation Management Plan (RMP) and Radiation Waste Management Plan (RWMP) will be prepared which will outline the management measures for return of waste materials to the mine void for later rehabilitation and to ensure worker and public radiation exposures are managed in accordance with the legislation.

Potential exposures and exposure routes to radiation included the assessment of:

- **Radiation exposure affecting the health of mine workers** – by inhalation of dust containing radionuclides, inhalation of radon, external gamma irradiation.
- **Radiation exposure affecting the health of process plant workers –** by inhalation of dust containing radionuclides, inhalation of radon, external gamma irradiation from the minerals separation process.
- **Radiation exposure affecting the health of members of the public**

The assessed likelihood, consequence and residual impact (as per Section 7.3), is provided below for each potential impact.

10.5.2.1 Radiation Exposure Affecting the Health of Mine Workers

Potential exposures for mine workers were estimated based on:

- Exposure to external gamma irradiation by general proximity to the NORMs.
- Inhalation of dust containing radionuclides (and hence exposure to otherwise short lived alpha particles).
- Inhalation of radon gas and radon decay products.

Radon is a gas which may accumulate in areas with reduced ventilation based on the concentration of uranium and the rate of air exchange. Potential exposures for mine workers by these exposure routes were estimated

(Radiation Professionals 2016, Appendix 21, summarised in Table 75) in comparison to the occupational exposure limit of 20 mSv/year (Regulation 16.18 *Mines Safety and Inspection Regulations 1995*).

Table 75: Summary of Estimated Mine Workers Radiation Exposure

Exposure Pathway	Unit	Calculated Dose	Guideline Value	Percentage Guideline
External Gamma	mSv/year	0.34	20	1.7 %
Dust Inhalation	mSv/year	0.11	20	0.55 %
Radon Inhalation	mSv/year	1.7	20	8.5 %
Total Exposure	**mSv/year**	**2.15**	**20**	**10.75 %**

Radiation exposure to mine workers is considered 'Almost Certain' within the Mine Site Development Envelope, but the total exposure is considered 'Incidental'. The potential residual impact of radiation on the health of mine workers, after implementation of the RMP and RWMP, is assessed as 'Medium'.

Impact	Consequence	Likelihood	Residual Impact
Radiation exposure affecting the health of mine workers	Incidental	Almost Certain	Medium

10.5.2.2 Radiation Exposure Affecting the Health of Process Plant Workers

Potential exposures for process plant workers were estimated based on:

- Exposure to external gamma irradiation by general proximity to the NORM materials.
- Inhalation of dust containing radionuclides (and hence exposure to otherwise short lived alpha particles).
- Inhalation of radon gas and radon decay products.

Exposures for process plant workers by these exposure routes were estimated (Radiation Professionals 2016, Appendix 21, summarised in Table 76) in comparison to the occupational exposure limit of 20 mSv/year (Regulation 16.18 *Mines Safety and Inspection Regulations 1995*). The assessment is considered conservative as it does not account for shielding from the equipment itself, a high general dust loading (e.g. 2 mg/m^3 in the crushing area) and that workers will spend 2,000 working hours in close proximity to these materials within the plant.

Table 76: Summary of Estimated Process Plant Workers Radiation Exposure

Exposure Pathway	Unit	Calculated Dose	Guideline Value	Guideline (%)
External Gamma	mSv/year	1.24	20	6.2 %
Dust Inhalation	mSv/year	0.25	20	1.25 %
Radon Inhalation	mSv/year	1.5	20	7.5 %
Total Exposure	mSv/year	**3**	**20**	**15 %**

Although radiation exposure to process plant workers is considered 'Almost Certain' within the Mine Site Development Envelope, the total exposure is considered 'Incidental'. The potential residual impact of radiation on the health of process plant workers, after implementation of the RMP and RWMP, is assessed as 'Medium'.

Impact	Consequence	Likelihood	Residual Impact
Radiation exposure affecting the health of process plant workers	Incidental	Almost Certain	Medium

10.5.2.3 Radiation Exposure Affecting the Health of Members of the Public

Potential exposures for members of the public may occur by means of external gamma irradiation (if in sufficiently close proximity to the products or waste material) or by inhalation of radionuclides within the dust.

Radon inhalation is not considered significant due to its rapid decay. As the only potential residence adjacent to the Mine Site Development Envelope is the Mt Jowlaenga pastoral homestead some 8 km away and the site access road is approximately 30 km from the Great Northern Highway, potential for gamma radiation exposure to the public in the vicinity of the Mine Site was considered extremely low.

Dust emissions from the project are expected to be primarily generated throughout the process of extracting the required mineral sands products during the concentration, heating and separation procedures and the generation of the waste by-products. The majority of the operations will be contained within the process buildings, which will utilise dust suppression and ventilation arrangements to minimise the potential for dust generation, and are very removed from any potential dust inhalation impacts on the public (30 km away) (Radiation Professionals 2016, Appendix 21). Local Aboriginal people will either be engaged as employees and therefore subject to normal personal radiation monitoring for mine/process workers or have only brief exposure to site conditions as visitors during active operations.

The guideline for exposure assessment to the public is 1 mSv/year (as opposed to 20 mSv/year for radiation workers) (ARPANSA 2002). Radiation waste management and rehabilitation post mining will ensure surface and environmental radiation levels are returned are within environmental screening (10 µGy/h) or determined background levels such that radiation exposure is incidental only and less than 1 mSv/year.

Radiation exposure to members of the public above background levels is considered 'Unlikely' within the Mine Site Development Envelope, and the total exposure is considered 'Incidental'. The potential residual impact of radiation on the health of members of the public and Traditional Owners, after implementation of the RMP and RWMP, is assessed as 'Low'.

Impact	Consequence	Likelihood	Residual Impact
Radiation exposure affecting the health of members of the public	Incidental	Unlikely	Low

10.5.3 Management Measures

A summary of key measures to address potential impacts on human health from radiation is shown in Table 77. No further management measures are considered necessary.

Table 77: Proposed Management Measures for Radiation on Human Health for the Mine Site Development Envelope

Potential Impact Requiring Management	Measure
Radiation affecting the health of employees and contractors	• The mine will be registered under the RSA with the Radiological Council and DMP and Sheffield will appoint a Radiation Safety Officer (RSO) to implement a Radiation Management Plan (RMP) and the Radiation Waste Management Plan (RWMP) on behalf of Sheffield. • Provision and maintenance of equipment and facilities for controlling radiation sources, including housekeeping, dust suppression and surface contamination control to maintain a duty of care to employees and the public. • A radiation monitoring program will be developed and implemented in consultation with Radiological Council and DMP. This will include monitoring of personal exposure for mine and process plant workers, hand held gamma monitoring and monitoring of airborne dust scintillation counting (Bq/m3) and radon.
Radiation affecting the health of members of the public	• Processing and mining wastes will be blended prior to final disposal as backfill within the mining excavation in accordance with a prepared RWMP. • Rehabilitated areas will be monitored to ensure radiation levels are within environmental screening criteria (10 µGy/h) or established pre-mining background levels.

Further detail regarding the assessment and management measures for the protection of human health are detailed in Appendix 21 (Radiation Professionals, 2016).

10.5.4 Predicted Outcome

The predicted dose to mine workers and process plant workers was conservatively estimated to be 2.15 mSv/year and 3 mSv/year respectively, which is well below the dose rate limit for radiation workers of 20 mSv/year. The predicted dose to a member of the public was considered to be negligible and below assessable levels.

All activities at the Mine Site associated with the project will be undertaken in accordance with the *Radiation Safety Act.* Sheffield will engage a Radiation Safety Officer (RSO) upon the implementation of a Radiation Management Plan (RMP) and a Radiation Waste Management Plan (RWMP), to implement periodic personal and environmental monitoring of radiation levels for formal reporting to the Radiological Council and the DMP.

Implementation of these arrangements will ensure that any potential radiation doses to workers, the public and the environment will be monitored, controlled and minimised to ensure that all legal requirements are met and that radiation doses are below regulatory limits.

Sheffield considers that the potential impacts of radiation to human health will be able to be adequately managed such that the objective (Section 10.5) will be met, and that the residual impacts are therefore acceptable.

11. ENVIRONMENTAL IMPACT ASSESSMENT - OTHER ENVIRONMENTAL FACTORS - PORT DEVELOPMENT ENVELOPE

Other relevant environmental factors for the Port Development Envelope comprise the following:

- Benthic Communities and Habitat.
- Marine Fauna.
- Terrestrial Environmental Quality.
- Human Health.
- Hydrological Processes.

Potential impacts for each factor are detailed in Sections 11.1 to 11.4.

Potential impacts to the Town of Broome and the Port of Broome were screened out from further assessment (Section 7.4) as they were either assessed as not likely to occur or were unlikely to have any discernible consequence on any factor different to background levels:

Stressor	Justification for Exclusion
Installation of mooring points or anchoring disturbing benthic communities	Impacts to benthic communities or habitats from anchoring or mooring will not occur, as vessels will use the existing Port of Broome wharf infrastructure.
Noise or light from construction and operational activities impacting birds or terrestrial fauna	No construction will be undertaken, and operational activities occur within the context of an existing operational port, so no additional significant light or noise emissions that will impact marine fauna will be generated.
Changes in hydrological regimes impacting Sawfish or Northern River Shark	Sawfish and Northern River Shark are found in proximity to the Derby Port Development Envelope, rather than the Broome Port.
Dust generation, product spillage, or radiation exposure affecting the terrestrial environment	Dust generation, product spillage and radiation exposure are not expected to occur at the Port of Broome as the products are packaged during transport and transfer to ocean-going vessels.
Disturbance of contaminated soils affecting the terrestrial environment	No construction will be undertaken, so no contaminated soils will be disturbed.
Radiation exposure or dust emissions affecting human health	Transport vehicles will bypass the Town of Broome, and be on a dedicated heavy vehicle road. The port is not located near to residential areas. Dust generation, product spillage and radiation exposure are not expected to occur at the Port of Broome as the products are packaged during transport and transfer to ocean-going vessels. Specific activity concentrations of products are below concentrations where transport and storage requires regulation.
Diesel particulate and gaseous vehicle emissions affecting human health	Transport vehicles will bypass the Town of Broome, and be on a dedicated heavy vehicle road. Any increases in particulate matter or gaseous emissions are unlikely to be measureable, and will occur outside of residential areas.
Hydrological processes	As products will be packaged, dust suppression during product storage and transfer will not be required. Water use at the Port of Broome is thus likely to be insignificant and could be met by existing water supply infrastructure at the Port.

Potential impacts to marine fauna from shipping in the Kimberley have been assessed as part of the overall shipping assessment for the Derby Port Development Envelope (Section 11.2.2.4).

11.1 BENTHIC COMMUNITIES AND HABITAT

The EPA's objective for benthic communities and habitat is "*to maintain the structure, function, diversity, distribution and viability of benthic communities and habitats at local and regional scales*".

11.1.1 Key Statutory Requirements, Environmental Policy and Guidance

Benthic communities and habitats are protected under Commonwealth and State legislation, primarily governed by the following Acts:

- *Environment Protection and Biodiversity Conservation Act 1999* (Cth).
- *Conservation and Land Management Act* 1984 (WA).
- *Environmental Protection Act 1986* (WA).
- *Fish Resources Management Act 1994* (WA).

In addition, the following policy and guidance statements were considered in the impact assessment for benthic communities and habitats:

- Environmental Assessment Guideline 3, *Protection of Benthic Primary Producer Habitats in Western Australia's Marine Environment (*EPA 2009b).
- Wetlands Conservation Policy for Western Australia (DPaW 1997).
- The Wetlands Policy of the Commonwealth Government of Australia (Commonwealth Government of Australia 1997).

The ESD lists 'Guidance Statement for Protection of Tropical Arid Zone Mangroves along the Pilbara Coastline (GS 1) (EPA 2001)' and 'Environmental Assessment Guideline 7 (EAG 7) *Marine Dredging Proposals* (EPA 2011)', but neither are relevant to the proposal. GS 1 specifically addresses the protection of tropical arid zone mangroves, habitats and dependent habitats along the Pilbara coastline from Cape Keraudren at the southern end of Eighty Mile Beach to Exmouth Gulf. EAG7 is not relevant as the Thunderbird Mineral Sands Project (the project) does not include dredging.

11.1.2 Assessment of Potential Impact

Potential impact pathways for benthic communities and habitats include:

- **Installation of mooring points disturbing benthic communities and habitats** - direct physical disturbance within the Derby Port limits.
- **Anchoring disturbing benthic communities and habitats -** direct physical disturbance occurring near the entrance to King Sound at the pilot boarding point from ocean-going vessel dropping anchor.

The waters of King Sound are not known to support seagrasses, macroalgae, corals or any other visible benthic primary producer due to the high turbidity and large tidal movements of the waters as detailed in Section 4.3.13.2. Mangrove communities along the shoreline of King Sound are widely represented within the Derby region.

Other potential impacts were screened out from further assessment (Section 7.4) as they were either assessed as not likely to occur or were unlikely to have any discernible consequence on any factor different to background levels:

Stressor	Justification for Exclusion
Land clearing	Derby is an operational port and export activities at Derby will utilise existing port infrastructure. A Product Storage Facility will be constructed on previously cleared land where a similar storage facility was located and this will not require clearing of mangroves. As such, there will be no direct disturbance to mangrove communities and no direct impact on benthic primary producer habitat at Derby Port as a result of the project.
Dust coating leaves of plants, affecting plant health	A sparse collection of young mangrove plants occur in the intertidal zone beside the Product Storage Facility. The nearest well-developed mangals are located beyond the Derby Port Development Envelope. A dust modelling study was conducted for the project (Atmospheric Solutions 2016). This study showed that deposited dust within the Port Development Envelope was around 3.5 g/m^2/month. However, the dust modelling is known to be very conservative due to the use of a set of generic assumptions, and is likely to represent the worst-case scenario. In a study by Chevron (2012), it was found that rainfall was likely to be the main factor affecting the health of plants and that plant health did not differ significantly with distance from the dust source. No impact on benthic primary producer habitat at Derby Port is expected as a result of this stressor.
Dust or spillage of product in the marine environment	This impact could only occur indirectly through dust or spillage affecting marine water quality, which in turn affects BPPH. As this stressor has been assessed as part of Marine Environmental Quality (see Section 9.1.2.2) and assessed as 'Low', it is not necessary to assess it again. The mineral sands products are environmentally benign and no impact to benthic communities or habitats is expected as a result of this stressor.
Hydrocarbon spillage in the marine environment	This impact could only occur indirectly through hydrocarbon spillage affecting marine water quality, which in turn affects benthic communities or habitats. As this stressor has been assessed as part of Marine Environmental Quality (see 9.1.2.3) and assessed as 'Low', it is not necessary to assess it again. No impact to benthic communities or habitats is expected as a result of this stressor.

The assessed likelihood, consequence and residual impact (as per Section 7.3), is provided below for each potential impact.

The EPA's Environmental Assessment Guideline No. 3 – Protection of Benthic Primary Producer Habitats in Western Australia's Marine Environment (EPA 2009b) has been considered. However, as this guidance relates to proposals that will result in irreversible loss of or serious damage to benthic primary producer habitats, it is not applicable to this Project.

11.1.2.1 Installation of Mooring Points Disturbing Benthic Communities and Habitat

For any benthic communities and habitat that may be present in the vicinity of the wharf mooring point or sea transfer point, there is potential for impact from the physical disturbance of the benthos during the installation of moorings. There is also potential for the minor operational impact of mooring lines dragging along the ocean floor in lower tides. Any impact associated with the installation and operation of moorings would be localised to the site of project disturbance. The wharf mooring zone and the sea transfer point are within the Port limits. The sites are located at the same sites previously used as mooring zones by Lennard Shelf Pty Ltd, and have been disturbed previously.

Any potential for indirect impact to any benthic communities and habitat through additional turbidity generated through installation of moorings has been addressed in Section 9.1.2.1.

Although it is possible that benthic invertebrate and burrowing organism habitat could be present in the area, there are no known seagrasses or corals within the port limits (Section 4.3.13.2). Any impacts to benthic habitats will be localised to the immediate vicinity of the moorings. Due to the low likelihood of significant benthic communities and habitat occurring in the vicinity of the wharf mooring zone and sea transfer point it is considered 'Unlikely' that the project will result in any discernible changes to the structure, diversity and distribution of benthic habitats and communities in King Sound. The potential residual impact from the installation and operation of mooring points to benthic habitats and communities, after implementation of management measures, is assessed as 'Low'.

Impact	Consequence	Likelihood	Residual Impact
Disturbance of benthic communities and habitat through installation of mooring points	Incidental	Unlikely	Low

11.1.2.2 Anchoring Disturbing Benthic Communities and Habitat

On average, an ocean-going vessel will visit King Sound less than once per week. It is necessary to take on board a pilot with local knowledge of the islands and topography of the Buccaneer Archipelago, the Sunday Straits, and King Sound. Therefore the ocean-going vessel will need to drop anchor at the pilot boarding point at the entrance to King Sound. The dropping of anchor will cause direct disturbance to any benthic communities and habitat present at this location.

The seafloor at the pilot boarding point is approximately 40 - 50 m deep. At this depth, the benthos would not be likely to support hard corals or seagrasses due to the lack of light penetration. It is possible that the seafloor in the area may support sparse distribution of sponges or habitat for burrowing invertebrates (see Section 4.3.13.2). However, disturbance will be localised to the pilot boarding point. This is the same pilot boarding point that was used by Lennard Shelf Pty Ltd, and is therefore likely to have been slightly disturbed previously.

Due to the likely absence of significant benthic communities and habitat in the vicinity of the pilot boarding point, it is considered 'Unlikely' that the project will result in any discernible changes to the structure, diversity or distribution of benthic habitats and communities in King Sound or adjacent waters. The potential residual impact from the anchoring of the vessel at the pilot boarding point to benthic habitats and communities, after implementation of management measures, is assessed as 'Low'.

Impact	Consequence	Likelihood	Residual Impact
Anchoring disturbing benthic communities and habitat	Incidental	Unlikely	Low

11.1.3 Management Measures

Management measures associated with physical disturbance of benthic communities and habitats are addressed below in Table 78. Management measures associated with indirect impact pathways for benthic communities and habitats have been addressed in Section 9.1.3.

Table 78: Proposed Management Measures for Benthic Communities and Habitat

Potential Impact Requiring Management	Measure
Installation of mooring points disturbing benthic communities and habitat	• Sheffield will either upgrade or replace existing moorings installed at transhipment vessel and ship loading points within Derby Port limits.

Potential Impact Requiring Management	Measure
Anchoring disturbing benthic communities and habitat	• Dropping anchor by ocean-going vessels outside King Sound to collect the pilot will be confined to the pilot boarding area approved by the relevant Port authority in order to minimise damage to benthic communities and habitats.

11.1.4 Predicted Outcome

Installation of new moorings may cause direct disturbance within the mooring zones, however this is unlikely to impact the overall function of any benthic communities or habitats within King Sound. Dropping of anchor by the ocean-going vessel at the pilot boarding point may cause localised damage to any benthic communities and habitats, but due to the low benthic light levels which are characteristic of deeper waters, it is considered that there will not be any change to the structure, function, diversity, distribution and viability of benthic communities and habitats.

Sheffield considers that the potential impacts of mooring point installation and anchoring on benthic communities and habitats will be able to be adequately managed such that the objective (Section 11.1) will be met, and that the residual impacts are therefore acceptable.

11.2 MARINE FAUNA

The EPA's objective for marine fauna is "*to maintain the diversity, geographic distribution and viability of fauna at the species and population levels*".

In May 2016, the (then) Department of the Environment (DoE) provided comment on the draft Environmental Scoping Document (ESD) prior to finalisation. It was specifically requested that the Public Environmental Review (PER) address potential impacts on five threatened marine species namely:

- *Megaptera novaeangliae* (Humpback Whale) - Vulnerable.
- *Glyphis garricki* (Northern River Shark) - Endangered.
- *Pristis clavata* (Dwarf sawfish) – Vulnerable.
- *Pristis pristis* (Largetooth Sawfish) – Vulnerable.
- *Pristis zijsron* (Green Sawfish) – Vulnerable.

The following presents an impact assessment of these and other marine species that are of conservation significance.

11.2.1 Key Statutory Requirements, Environmental Policy and Guidance

Marine fauna are protected under Commonwealth and State legislation, primarily governed by three Acts:

- *Wildlife Conservation Act 1950* (WA).
- *Environmental Protection Act 1986* (WA).
- *Environment Protection and Biodiversity Conservation Act 1999* (Cth).

Sawfish species and Northern River Shark are also totally protected under the:

- *Fish Resources Management Act 1994* (WA).

In addition to State and Commonwealth legislation, the following policy, legislation and guidance statements were considered in the impact assessment for marine fauna:

- *Protection of the Sea (Prevention of Pollution from Ships) Act 1983.*
- *Pollution of Waters by Oil and Noxious Substances Act 1987.*
- EPA Guidance Statement No. 33, Environmental Guidance for Planning and Development (EPA 2008).
- Marine Bioregional Plan for the North-West Marine Region (DSEWPC 2012b).
- Threat Abatement Plan for the Impacts of Marine Debris on Vertebrate Marine Life (DEWHA 2009).
- Threat Abatement Plan for the Impacts of Marine Debris on Vertebrate Marine Life: Review 2009-2014 (DoE 2014).
- Sawfish and River Sharks Multispecies Recovery Plan (DoE 2015a).
- Sawfish and River Sharks. Multispecies Issues Paper. Commonwealth of Australia. (DoE 2015b).
- International Convention for the Prevention of Pollution from Ships (MARPOL), 1973; Annex V, 2013.
- Environmental Assessment Guideline 5, Protecting Marine Turtles from Light Impacts (EPA 2010).

11.2.2 Assessment of Potential Impact

In considering the potential impacts to Humpback Whales, the Marine Bioregional Plan for the North-west Marine Region (DSEWPC 2012b) was taken into account. The issues of concern for Humpback Whales related to this project were specifically associated with vessel strike and vessel noise impacts.

The potential impacts to Sawfish species and the Northern River Shark in the North-west bioregion are discussed in the Sawfish and River Sharks Multispecies Issues Paper (DoE 2015b). The threats of potential concern to these species related to this project are changes to hydrological regimes (such as groundwater drawdown or impediments to surface water flows) and solid waste/marine debris (entanglement in wastes released to the marine environment).

Impacts to other marine fauna such as marine reptiles, dolphins and seabirds were also assessed using the Marine Bioregional Plan for the North-west Marine Region (DSEWPC 2012b).

In addition to marine fauna, several coastal/terrestrial species that are listed as threatened may occur in the Derby Port Development Envelope. Of these, 10 species are birds and two are terrestrial mammals (Section 4.3.10.2). As the potential impacts to marine fauna may also affect these species, they included in the assessment here.

The assessed likelihood, consequence and residual impact (as per Section 7.3), is provided below for each potential impact.

The sources of potential impact to marine fauna include the following activities:

- **Noise from construction and operational activities at Derby Port impacting birds or terrestrial fauna** – noise from construction/upgrade of export facilities and operation of export facilities causes impacts to birds or terrestrial fauna
- **Light from construction and operational activities at Derby Port impacting birds or terrestrial fauna** – light from construction/upgrade of export facilities and operation of export facilities causes impacts to birds or terrestrial fauna
- **Changes in hydrological regimes at the Mine Site Development Envelope impacting Sawfish species or Northern River Shark** – caused by excessive groundwater or surface water abstraction or construction of weirs.

- **Additional shipping and transhipment impacting marine fauna** – these could be direct or indirect through:
  - Vessel strike.
  - Noise.
  - Light.
  - Hydrocarbon spill.
  - Solid waste/marine debris.

11.2.2.1 Noise from Construction and Operational Activities at Derby Port Impacting Birds or Terrestrial Fauna

Although several marine fauna species are known to occur at Derby Port, the area is not considered important habitat for any species (see Section 4.3.14). Any noise disturbance caused by the construction of the Product Storage Facility and upgrade of export facilities is likely to be of a local and temporary nature. Additional pile driving is not required. The Derby Port Development Envelope is an already disturbed site in an existing industrial area. The storage facility to be constructed will utilise the same footprint as a previous shed by Lennard Shelf Pty Ltd.

Derby Port Development Envelope is not encroaching on any habitats of particular significance for migratory birds. Derby sewage ponds are listed as important habitat for the Little Curlew; however there will be no impact from the project on the Derby sewage ponds which are approximately six kilometres away from the Product Storage Facility.

As shown in Figure 42, the closest habitats of significance for migratory birds to any shipping corridors are the North-west and South-east Islands. These islands are approximately eight kilometres southwest of the pilot boarding point, where the ship will enter King Sound.

No discernible change to breeding patterns or behaviour is expected, however some short term disruption of marine fauna in the immediate vicinity of project infrastructure is considered 'Possible'. The potential residual impact of noise on marine fauna, after implementation of management measures, is assessed as 'Low'.

Impact	Consequence	Likelihood	Residual Impact
Noise from construction and operational activities at Derby Port impacting birds or terrestrial fauna	Incidental	Possible	Low

11.2.2.2 Light from Construction and Operational Activities at Derby Port Impacting Birds or Terrestrial Fauna

Derby Port is an existing and operating industrial facility and already has functioning lighting in place. There are large street lights several metres tall at regular intervals along the wharf itself with additional lights on the western shore of the wharf near the conveyor. The roads and footpaths around the export facility and storage facility are also well-lit with street lighting. Additional lighting will need to be installed to allow the 24 hour per day operation of the Product Storage Facility and export infrastructure. It is expected that the level of lighting installed will not significantly exceed lighting that was in place at the site previously for Lennard Shelf Pty Ltd.

Marine fauna such as turtles and migratory birds are sensitive to artificial lighting (EPA 2010). Nesting turtles can be discouraged from nesting on lit beaches, whilst turtle hatchlings can be disorientated by artificial lights. However, the habitats of the Derby Port Development Envelope are not suitable nesting habitats for turtles and although non-nesting turtles may occasionally pass near the wharf, the behaviour and breeding patterns of turtles are not at risk from artificial lighting at the Port.

Artificial lighting may similarly disorientate migratory seabirds and shorebirds that are active at night, causing collisions with infrastructure or starvation due to incorrect navigation. The North-west Marine Bioregional Plan lists species for which light pollution is of "potential concern" (DSEWPC 2012b). Of these species, there are 11 species that are known to occur or may occur around the Derby Port Development Envelope. One of these species is listed as threatened and migratory, the Curlew Sandpiper. This species is known to occur in the Port Development Envelope although it is not a breeding site (DoE 2016).

There are 10 other migratory and non-threatened species that may occur and may be affected by light pollution (DSEWPC 2012b). Of these species, only the Little Tern has potential breed near the Derby Port Development Envelope. A small percentage of Little Terns occurring in northwest Australia are part of the breeding population, with the majority being non-breeding migrants. Breeding pairs of the Roseate Tern and Lesser Frigate are known to occur on some on islands in the Buccaneer Archipelago (DoE 2016, Birdlife 2016).

Information from the EPA (2010) suggests best practice methods from implementing lighting. This guideline suggests keeping lighting off when not needed, mounting lights as low as possible and with the lowest intensity needed for the job, ensuring lighting is shielded to prevent light escaping outwards and upwards and use long wavelengths where possible. This guideline will be considered in any additional lighting installations.

Given that the Derby Port Development Envelope is an existing industrial area with existing lighting, the additional lighting is not likely to result in the loss of conservation significant fauna habitat; nor the loss of individuals of a conservation significant species. No discernible change to breeding patterns or behaviour is expected, however some short term disruption of marine fauna in the immediate vicinity of project infrastructure is considered 'Possible'. The potential residual impact of light on marine fauna, after the implementation of management measures, is assessed as 'Low'.

Impact	Consequence	Likelihood	Residual Impact
Light from construction and operational activities at Derby Port impacting birds or terrestrial fauna	Incidental	Possible	Low

11.2.2.3 Changes in Hydrological Regimes Impacting Sawfish or Northern River Shark

Sawfish species and the Northern River Shark are known to venture up rivers to brackish conditions. The Largetooth Sawfish is known to utilise completely freshwater habitats at certain life stages, and has been found as far inland as 400 km (DoE 2015b). Fraser River South has been identified as the only inland habitat associated with the proposal where juvenile Largetooth Sawfish are predicted to occur during the wet season. This watercourse is not considered potential habitat for other Sawfish species or the Northern River Shark (DoE 2015b).

In certain projects, the alteration of flow in rivers due to groundwater drawdown and the installation of weirs or impoundments can severely compromise the habitats and behaviour of Sawfish species. A reduction in the dry season flows of rivers could restrict the habitat availability for the Sawfish species and Northern River Shark (DoE 2015b).

The river channel extends to approximately 10.5 km from the Mine Site Development Envelope and will be crossed by Site Access Roads at the existing Mt Jowlaenga Road crossing and 1.7 km upstream of this point. The portion of the river within the Mine Site Development Envelope is at the uppermost reaches of the catchment. The river in this section is an ephemeral, poorly incised, shallow watercourse typical of upper catchments that carry low flow volumes infrequently after significant rainfall (Figure 26).

The only physical impact on the river channel will be the Site Access Road crossing which will be fitted with suitable culverts to allow wet season flows to pass. These culverts would also allow the movement of juvenile Sawfish, should they venture this far upstream in the wet season. The river channel at the point of crossing the Site Access Road is shown in Figure 26.

The catchment area of the Fraser River South upstream of the first visible channel is approximately 300 km^2. Any reductions in runoff from water capture in active mining areas will have negligible hydrologic impact. Maximum groundwater drawdown at the Fraser River South headwaters is predicted to be less than 2 m over the life of the project, which would result in minimal impact on wet season surface flows. Since this channel is naturally dry during the dry season, there will be no change to dry season flows.

Fraser River South is potential habitat for the Largetooth Sawfish in the wet season only. The closest section of the river is 10.5 km from the main mining operation and it will be crossed by the Site Access Road. The maximum drawdown in the catchment headwaters is expected to result in minimal impact to wet season surface flows. The project is expected to result in no discernible loss of conservation significant fauna habitat, loss of individuals, or interruption to breeding patterns or behaviour. Impact to Sawfish and Northern River Sharks is 'Unlikely'. The potential residual impact from changes in hydrological regimes to Sawfish and the Northern River Shark, after implementation of management measures, is assessed as 'Low'.

Impact	Consequence	Likelihood	Residual Impact
Changes in hydrological regimes impacting Sawfish or Northern River Shark	Incidental	Unlikely	Low

11.2.2.4 Additional Shipping or Transhipment Impacting Marine Fauna

Shipping is an existing and well-established industry in the Kimberley. In the year 2014/15, a total of 1,515 vessels were known to berth at the deep water Kimberley ports of Broome and Wyndham and the tidal port of Derby (see Table 32). The project will bring an additional 40 - 70 ocean-going vessels to the Kimberley each year. Taking the conservative higher number of 70 additional vessels per year, this represents a maximum increase in 4.6% per year of ships navigating the waters of the Kimberley.

Within the Derby Port limits, the vessel movements will be restricted to transhipment vessels towed by tug boats. Tug boats and transhipment vessels already regularly visit the area and travel at slow speeds. As Derby Port is already an existing port, and considering the number of recreational vessels which are not included in the data, the increase in transhipment vessel and tug movements is expected to present a limited additional impact. The method of transhipment will be very similar to that used by Lennard Shelf Pty Ltd which operated with no major incidents.

Vessel Strike from Additional Shipping Impacting Marine Fauna

Vessel strike or collision with marine fauna is a known cause of deaths or injuries to marine fauna such as Whales, Inshore Dolphins and Sea Turtles. Species at risk of vessel strike by project vessels would include Humpback Whales, Australian Humpback Dolphins, Indo-Pacific Bottlenose Dolphins, Snubfin Dolphins, Flatback Turtles, Green Turtles, Loggerhead Turtles, Olive-Ridley Turtles and Leatherback Turtles.

The areas considered of higher risk of vessel strike would be the areas outside the port limits where the water is less turbid and more wildlife is likely to occur. The slow-speed movements of transhipment vessels and tugs inside the port limits are less likely to result in vessel strike.

Humpback Whales migrate along the West Australian coast to calving grounds in the Kimberley. Surveys show that whales remain offshore, passing King Sound and aggregate at the Frost and Tasmanian Shoals and Camden Sound (Jenner *et al*. 2001). Ocean-going vessels entering King Sound to moor at the sea transfer point will pass through the migration path and potential calving grounds of the Humpback Whale. As Humpback Whales are not known to use the southern part of King Sound where transhipment vessel movements will occur, the only potential interaction with Humpback Whales is from the ocean-going vessels coming to and from the sea transfer point.

The ocean-going vessels are not expected to pass through any of the three zones where the highest concentrations of whales occur, which are the Lacepede Islands, the Frost and Tasmanian Shoals and Camden Sound (ellipses as shown on Figure 42). Given that Humpback Whales are only present in the area for four to five months per year; this would mean a maximum of an additional 16 vessels would be crossing the whale migration path each year.

Inshore Dolphins are also considered at risk from vessel strike, with the risk increasing with speed of the vessel. Reports indicate that there have previously been collisions between Dolphins and boats in the northwest region. Vessel strike is also known to cause death or injury to Sea Turtles in Australia, although there are few quantifiable data specifically in the region. The species' poor hearing and vision can affect their ability to avoid boats (DSEWPC 2012d).

Several measures will be put in place to minimise harm to marine fauna. If crew of Sheffield operated vessels sight cetaceans or sea turtles, these will be reported to other vessels to ensure they are informed and can take precautions in the area. Captains of ocean-going vessels will be informed to take extra care during the Humpback Whale migration season (July to November), adjust vessel speeds and have crew on watch as needed. Sheffield operated vessels will reduce speed below 8 knots if whale sightings are within vessel movement areas. Any potential impacts to Humpback Whales will be managed through the Port Environmental Management Plan (EMP). Any wildlife strikes by Sheffield operated vessels will be reported through the Port EMP and adaptive management practices implemented if necessary.

Shipping in the Kimberley is an established industry and this project represents a small percentage increase in vessel movements. Vessels will need to cross the Humpback Whale migration path, and will also pass through areas where Dolphins and Turtles are likely to occur. It is 'Possible' that vessel strike could cause the death of an individual animal of a conservation significant species, although this would not impact on the population's ability to survive locally. The potential residual impact of vessel strike on Humpback Whales, Dolphins and Sea Turtles, after implementation of management measures, is assessed as 'Low'.

Impact	Consequence	Likelihood	Residual Impact
Vessel strike from additional shipping impacting marine fauna	Incidental	Possible	Low

Noise from Additional Shipping Impacting Marine Fauna

Noise related to shipping has been shown to have a damaging affect to some cetaceans. Noise impacts to Humpback Whales are considered of potential concern according to DSEWPC (2012) as the frequency of shipping noise directly overlaps with the frequency range of some baleen whales. Rolland *et al.* (2012) found that Right Whales (*Eubalaena glacialis*) in the USA exhibited increased stress with an increase in shipping noise in a high shipping traffic area. Similarly, noise may also impact Inshore Dolphins, including potentially limiting the detection of natural sounds, disturbing normal behaviours and masking communication including the whistles required for social interactions. Dolphins may exhibit vessel avoidance behaviour due to vessel noise. Noise impacts from shipping are also a potential concern for Sea Turtles (DSEWPC 2012d).

The increase in shipping movements from the project will be equivalent to less than one additional vessel per week during the whale migration, meaning that noise impacts will be intermittent. Other species that would be susceptible to noise impacts (i.e. Inshore Dolphins and Sea Turtles) are not found in the area of the sea transfer point in large numbers and the proposed route of the ocean-going vessel will not pass close to any habitats of particular significance for these species (see Figure 42).

The project only represents an addition of 2.6% to the vessel movements of the Kimberley (based on 2014/15 data). It is 'Possible' that noise from additional shipping could result in short term, intermittent disruption of marine fauna breeding and/or behavioural patterns that do not affect population health or survival. The potential residual impact of noise from additional shipping on marine fauna, after the implementation of management measures, is assessed as 'Low'.

Impact	Consequence	Likelihood	Residual Impact
Noise from additional shipping impacting marine fauna	Incidental	Possible	Low

Light from Additional Shipping Impacting Marine Fauna

When the ocean-going vessel is moored at the sea transfer point, it will need lighting at night. This is a DoT requirement and necessary for navigational safety. Lighting will also be required to allow 24 hour a day loading of the ocean-going vessel from the transhipment vessel.

Sea Turtles are sensitive to artificial lighting (EPA 2010). Nesting turtles can be discouraged from nesting on lit beaches, whilst turtle hatchlings are disorientated and can be attracted by artificial lights. The coastline nearest the sea transfer point at Point Torment is likely suitable nesting habitat for Flatback Turtles (R.I. Prince, pers. comm. cited in SWOT 2009). However, this is not considered a nesting habitat of particular significance.

As discussed above in Lighting – Derby Port, artificial lighting may similarly disorientate migratory seabirds and shorebirds that are active at night. The North-west Marine Bioregional Plan lists species for which light pollution is of "potential concern" (DSEWPC 2012b). Of these species, there are 11 species that are known to occur or may occur in the shipping or transhipment route or around the Derby Port Development Envelope. One of these species is listed as threatened and migratory, the Curlew Sandpiper. This species is known to occur in the shipping or transhipment route or around the Derby Port Development Envelope although it is not a breeding site (DoE 2016). The nearest breeding site of significance to the shipping or transhipment route is the North-west and South-east Islands, which are significant breeding sites for the Roseate Tern (Birdlife 2016). These islands are located approximately eight kilometres from the pilot boarding point, and light impacts to this site will be insignificant.

The chance of additional lighting causing disturbance to marine fauna is considered 'Unlikely'. The lighting associated with additional shipping is not likely to result in the loss of conservation significant fauna habitat; nor the loss of individuals of a conservation significant species. No discernible change to breeding patterns or behaviour of marine fauna is expected. The potential residual impact of light from additional shipping on marine fauna, after the implementation of management measures, is assessed as 'Low'.

Impact	Consequence	Likelihood	Residual Impact
Light from additional shipping impacting marine fauna	Incidental	Possible	Low

Hydrocarbon Spill from Additional Shipping Impacting Marine Fauna

In the event of a hydrocarbon spill, species potentially at particular risk would include Inshore Dolphins, seabirds and shorebirds and Sea Snakes (DSEWPC 2012b).

This impact could only occur indirectly through hydrocarbon spillage affecting marine water quality, which in turn affects marine fauna. This stressor has been assessed as part of Marine Environmental Quality (see Section 9.1.2.3) and given the management and mitigation measures addressed in that section, has been assessed as 'Low'.

It is 'Unlikely' that a hydrocarbon spill in King Sound or adjacent waters could result in the death of an individual animal of a conservation significant species. If it did occur, it would not be expected to impact on the population's ability to survive locally. The potential residual impact of a hydrocarbon spill from additional shipping on marine fauna, after implementation of management measures, is assessed as 'Low'.

Impact	Consequence	Likelihood	Residual Impact
Hydrocarbon spill from additional shipping impacting marine fauna	Incidental	Possible	Low

Solid Waste/Marine Debris from Additional Shipping Impacting Marine Fauna

Marine debris includes all non-biodegradable solid waste from commercial and recreational shipping, land-sourced garbage, discarded fishing gear and "ghost nets" – pieces of fishing nets floating in the sea. Historically, the commercial shipping industry has been responsible for the discharge of large amounts of solid waste which in turn becomes marine debris. Marine debris is a potential impact of concern to marine fauna, as they can ingest it or become entangled, resulting in death or injury. This process is listed as a "Key Threatening Process" in the *EPBC Act* (DEWHA 2009). Marine debris is of particular concern for the Sawfish species (DoE 2015a). Due to their barbed rostrum, these species are known become entangled in marine debris, causing death or injury.

According to International Convention and Commonwealth and State laws, it is illegal to dump garbage from ships into the sea except under very specific circumstances. Amendments to *the International Convention for the Prevention of Pollution from Ships (MARPOL) Annex V* came into force on 1 January 2013. This amendment reversed the presumption that dumping at sea was allowed, except in specific areas. MARPOL is administered in Australian waters through the *Protection of the Sea (Prevention of Pollution from Ships) Act 1983*. In Western Australia, the *Pollution of Waters by Oil and Noxious Substances Act 1987* also applies.

Solid waste facilities are provided at the Derby Port. All crew on the Sheffield transhipment vessel and tug boat teams will be made aware of the importance of preventing the escape of solid waste. All solid waste will be disposed of in appropriately covered receptacles at Derby Port and transferred to a licensed disposal facility. The Captain of the ocean-going vessel will be provided with information on the legal obligations of preventing the escape of solid waste. The management of solid waste and all debris will be covered in the Port EMP.

Solid waste and marine debris are considered 'Unlikely' to result in either the loss of individuals of a conservation significant species or the loss of conservation significant fauna habitat; or disruption to marine fauna breeding patterns or behaviour. The potential residual impact of solid waste/marine debris from additional shipping on marine fauna, after the implementation of management measures, is assessed as 'Low'.

Impact	Consequence	Likelihood	Residual Impact
Solid waste/marine debris from additional shipping impacting marine fauna	Incidental	Unlikely	Low

11.2.3 Management Measures

Management measures to reduce potential impacts to marine fauna are addressed in the Port EMP.
The ESD states that a Humpback Whale Management Plan should be produced if needed. As all potential impacts to Humpback Whales have been assessed as 'Low', it is not considered necessary to produce a stand-alone management plan for this factor. However, any potential impacts to Humpback Whales will be addressed in the Port EMP along with all other marine factors.

Key management measures related to marine fauna are detailed below in Table 79.

Table 79: Proposed Management Measures for Marine Fauna

Potential Impact Requiring Management	Measure
Lighting from Port and vessels	• Lighting design will consider minimisation of attraction of wildlife. • Operators of the ocean-going vessel will be made aware of potential lighting impacts to marine fauna and the advice of Environmental Assessment Guideline No. 5, Protecting Marine Turtles from Light Impacts (EPA 2010).
Inland Hydrological Change affecting Sawfish	• Culverts will be constructed at the channel of the Fraser River South where it crosses the Site Access Road to facilitate wet season surface water flows and allow the passage of juvenile Sawfish.
Vessel Strike	• If crew of Sheffield operated vessels sight cetaceans or sea turtles, these will be reported to other vessels to ensure they are informed and can take precautions in the area. • Captains of ocean-going vessels will be informed to take extra care during the Humpback Whale migration season (July to November), adjust vessel speeds and have crew on watch as needed. • Sheffield operated vessels will reduce speed below 8 knots if whale sightings are within vessel movement areas. • Any wildlife strikes by Sheffield operated vessels will be reported through an incident reporting system and adaptive management practices implemented if necessary.
Hydrocarbon Spill	• All Sheffield marine vessels will be maintained to high standards as required by DoT. Refuelling of marine vessels will be consistent with Port of Derby criteria. • Refuelling equipment will include emergency shutdown valves and be monitored at all times. • Used oil or oil-soaked absorbents will be securely stored and disposed of at a licensed facility. • Spills of oil, fuel or other hydrocarbons to water will be immediately reported to DoT. • A spill kit located at Derby Port will be maintained in working order. • An appropriately sized and stocked marine spill kit will be located on each Sheffield owned or operated tug boat to address small scale spillages.
Solid waste/marine debris	• Employees and contractors operating Sheffield transhipment vessel and tug boat teams will be made aware of the importance of preventing the escape of solid waste. • Solid waste will be disposed of in appropriately covered receptacles at Derby Port and transferred to a licensed disposal facility. • The Captain of the ocean-going vessel will be provided with information on the legal obligations of preventing the escape of solid waste.

11.2.4 Predicted Outcome

Derby Port is an existing facility and the transhipment and shipping routes have been used historically. The increase in shipping movements is minimal, representing an additional 2.6% per year (based on the year 2014/15). This minimal increase in vessel movements will result in negligible increases in noise and light emissions or solid waste impacts. Therefore, it is not anticipated that these minimal increases will result in any loss of conservation significant fauna habitat or individuals of a conservation significant species, or change to breeding patterns or behaviour of marine fauna.

Whilst hydrocarbon spills and vessel strikes could result in the death of an individual animal of conservation significance, it is unlikely that such an event would occur and it is not anticipated that this would affect the ability of the population of that species to survive in King Sound or the vicinity.

Sheffield considers that the potential impacts of the project on marine fauna will be able to be adequately managed such that the objective (Section 11.2) will be met, and that the residual impacts are therefore acceptable.

11.3 TERRESTRIAL ENVIRONMENTAL QUALITY

The EPA's objective in relation to terrestrial environmental quality is "*to maintain the quality of land and soils so that the environment values, both ecological and social, are protected*".

11.3.1 Key Statutory Requirements, Environmental Policy and Guidance

Key statutory requirements, environmental policy and guidance for Terrestrial Environmental Quality, in relation the Derby Port Development Envelope, are the same as for the Mine Site Development Envelope, see Section 10.3.1.

11.3.2 Assessment of Potential Impact

The bulk ilmenite and zircon concentrate products will be transported from the Mine Site to Derby Port for export via King Sound. Terrestrial environmental quality along the transport route and at the Derby Port has the potential to be impacted from transport, storage and export of product activities such as:

- **Dust generation or spillage of product affecting the terrestrial environment** – could occur at the Derby Port or transport route.
- **Radiation exposure affecting the terrestrial environment** – as a result of a spill.
- **Disturbance of contaminated or acid sulfate soils affecting the terrestrial environment** - during construction of the Product Storage Facility.

Other potential impacts were screened out from further assessment (Section 7.4) as they were either assessed as not likely to occur or were unlikely to have any discernible consequence on any factor different to background levels:

Stressor	Justification for Exclusion
Uncontrolled drainage from Product Storage Facility	Terrestrial pollution will not be caused through uncontrolled drainage. The Product Storage Facility will either be a fully enclosed, concrete floored facility or silos. Drainage within the shed will be directed to sumps. Materials collected in the sumps will be removed as needed and returned to the Mine Site for reprocessing. Shed doors will only open to allow entry and exit of road trains. Product to be stored is insoluble and considered environmentally benign.
Disturbance of contaminated soils or acid sulfate soils (ASS) affecting the terrestrial environment	Assessment of the soils and sediments within the lease area which may be disturbed in minor volumes by construction of a Product Storage Facility indicated no significant risk of ASS. As the site is already levelled, very minimal disturbance of soils is expected other than for installation of services and minor foundations works as required. No significant disturbance of marine sediment and hence opportunity for oxidation and metals/metalloids release is expected for the proposed development as the wharf is already constructed.

The assessed likelihood, consequence and residual impact (as per Section 7.3), is provided below for each potential impact.

11.3.2.1 Dust Generation or Product Spillage Affecting the Terrestrial Environment

The potential impact of dust on human receptors is addressed in 9.2.2.1.

The terrestrial environment may be affected by dust or deposition or a spillage of product along the transport route or at the Derby Port Development Envelope. Dust is likely to be generated during construction of the Product Storage Facility subject to site conditions at the time. During the operational phase, dust could be generated from transportation of product in road trains to the product export facility and potentially from export activities. Spillage could result from incorrect filling or tipping of road trains.

There will be an average of 10 return road train trips (20 road train movements) along the transportation route per 24 hour period during the operational phase of the project. Other than the Site Access Road, road trains accessing the Derby Port Development Envelope from the Mine Site will be travelling on sealed roads and dust generation is expected to be minimal. Bulk product will be transported in covered containers. Mineral sands products are naturally occurring and environmentally benign as they are insoluble and not readily prone to dust generation. In the event of any spilt material (e.g. truck rollover), this would represent a very low risk to the terrestrial environment. Material spilt would be collected and returned to site for re-processing and dust suppression measures would be applied during this clean-up and recovery as necessary.

Sensitive receptors in the terrestrial environment may include conservation significant flora, fauna, and soils. Long term exposure to excessive dust levels can affect flora and fauna health. There are no listed threatened species of flora located within the Derby Port Development Envelope or transportation route. There are eight species of listed threatened terrestrial fauna that may occur in the Derby Port Development Envelope. Six of these are birds and two are mammals. Due to a lack of unsuitable habitat, most of these are expected to be infrequent visitors. The causeway across the mudflats between the Port and Derby townsite was constructed from local rock and soil sourced from the Derby hinterland. All soil at the proposed storage facility area consists of fill material, primarily Pindan soil imported and placed in 1997 as part of construction works for the former lead and zinc concentrate storage facility. Although this soil fill shows some residual levels of lead and zinc from previous activities (MBS 2016c, Appendix 14), the dust generated by disturbance of this soil is not environmentally damaging.

Impacts from dust generation are likely to be limited to within 50 m of the generation point. Dust modelling has been conducted for the project in the section of road between Derby town and the Product Storage Facility. In the absence of specific detailed inputs for the model, the modelling has adopted standard emissions and is therefore likely to be an over-estimate. Average monthly dust deposition in Derby town will be 0.5 - 0.8 g/m^2/month and 3.5 - 4 g/m^2/month at the Port (Atmospheric Solutions 2016; Appendix 17). This level (equal to or below human amenity levels), is not considered significant for flora or fauna (or human) health.

Product dust escaping during storage and transfer of bulk mineral sands products will be minimal. The export products have limited potential for dust generation as they are granular in nature and do not contain fines and have high specific gravities. They are highly insoluble materials and do not contain leachable contaminants such as heavy metals, hydrocarbons or acids.

The Product Storage Facility to be constructed will be purpose designed and will be fully enclosed which will prevent product dust escaping. The facility will store up to 50,000 to 60,000 tonnes of mineral sands products, and will accommodate all unloading and storage activities. If a shed facility is constructed, road trains will drive through the warehouse and tip into a specific product drop area. A front end loader will feed a hopper/conveyor system which runs the length of the shed and feeds the transhipment vessel loading conveyor. The conveyer system is covered to minimise loss or spillage of product.

Minor dust generation within the Derby Port Development Envelope is not considered a risk to the terrestrial environment given the impact of previous activity on the site, nature of the material and the lack of sensitive environmental receptors within close proximity to dust generation points.

Although some dust generation or spillage of product may occur, it is considered 'Unlikely' that it will result in any loss of soil resources or environmental values, or cause land contamination. The potential residual impact of dust generation and deposition on terrestrial environmental quality, after implementation of management measures, is assessed as 'Low'.

Impact	Consequence	Likelihood	Residual Impact
Dust generation or product spillage affecting the terrestrial environment	Incidental	Unlikely	Low

11.3.2.2 Radiation Exposure Affecting the Terrestrial Environment

The radioactivity levels of naturally occurring radioactive materials (NORMs) in exported products is less than 10 Bq/g with the primary product by volume (ilmenite) having an activity of less than 1 Bq/g (SGS 2016; Appendix 21). Zircon concentrates have a somewhat higher activity of up to 9.10 Bq/g but will be bagged and represent only a small proportion of material exported (e.g. primary zircon 8,227 tpa in Stage II, approximately 1%).

In accordance with Australian Radiation Protection and Nuclear Safety Agency (ARPANSA 2005) and International Atomic Energy Agency Safety Guide RS-G-1.7 (IAEA 2004), materials containing NORMs are excluded from regulations and considered inherently safe if the specific activity concentrations are below 1 Bq/g. Concentrations of NORM up to 10 Bq/g are generally considered exempt in relation to transport restrictions due to the nature of the materials and form of radiation (alpha rather than gamma) primarily emitted (ARPANSA 2008). The potential impact to the terrestrial environment from naturally occurring radioactive materials is therefore extremely small and will not require special consideration and management. Background radiation levels in soil, sediments and airborne dust will be measured prior to construction commencing.

Minor spillages of low radioactivity ilmenite material would be of negligible impact to the terrestrial environment of Derby Port Development Envelope. In the unlikely event of a major spill, the product will be recovered and returned to the Mine Site for re-processing.

There is very minor potential for impact to the surface terrestrial environment from significant spillage without appropriate clean-up of the zircon products, in particular the primary zircon which may exceed environmental screening criteria of 10 µGy/h if left at surface in large amounts. Any such environmental effects would take years to decades and also be unlikely due to the limited area of any impact. Risk of general emissions are unlikely due to transport of zircon being in small quantities and packaged in bags and hence very unlikely to be release dust. If a bag is split or lost during transport, the product will be recovered and returned to the Mine Site for re-processing. Cleanup will be conducted in conjunction with validation testing of remaining surface soils to ensure levels of radiation have returned to background levels away from the spill location. Recovered material will either be returned to the Product Storage Facility or returned to the Mine Site for reprocessing or disposal.

Short term exposure of terrestrial flora and fauna within a very limited spatial area during this process to low levels of activity is not considered to be of significant impact. All products also have a specific gravity higher than 4.7 and are therefore not susceptible to dispersion as dust.

The products have very low to insignificant levels of natural radiation. It is considered 'Unlikely' that radiation will result in any loss of soil resources or environmental values or cause land contamination. The potential residual impact from radiation on terrestrial environmental quality, after implementation of management measures, is assessed as 'Low'.

Impact	Consequence	Likelihood	Residual Impact
Radiation exposure affecting the terrestrial environment	Incidental	Unlikely	Low

11.3.2.3 Disturbance of Contaminated Soils Affecting the Terrestrial Environment

The Product Storage Facility site has a history of contamination and was remediated in 2010/11 after which it was deemed to be remediated to a level that is appropriate for its intended land use (industrial/commercial) (MBS 2012). The site remains classified as 'Possibly Contaminated – Investigation Required' due to a lack of groundwater data from beneath the site (which is affected by tidal intrusion). A baseline contamination assessment of the Derby Port Development Envelope in 2016 (MBS 2016c; Appendix 14), found levels of potential contaminants to be below Environmental Investigation Levels and Health Investigation Levels values and soils and subsoil clays were not potentially ASS (Section 4.3.7).

The project is expected to result in no loss of soil or land resources or associated terrestrial environmental values as a result of construction of the Product Storage Facility. Impacts associated with ASS are assessed as 'Unlikely'. The potential residual impact from ASS on terrestrial environmental quality, after implementation of management measures, is assessed as 'Low'.

Impact	Consequence	Likelihood	Residual Impact
Disturbance of contaminated soils or acid sulfate soils affecting the terrestrial environment	Incidental	Unlikely	Low

11.3.3 Management Measures

Management measures implemented to minimise the potential impact on terrestrial environment quality have been identified in Table 80.

Table 80: Proposed Management Measures for Terrestrial Environmental Quality

Potential Impact Requiring Management	Measure
Dust generation or product spillage	• Bulk products will be transported in covered containers. • Bulk product will be stored in a purpose built Product Storage Facility. This will include a drive through enclosed unloading area to ensure product is contained within warehouse during unloading activities. • Product storage and loading onto the conveyor will be conducted within the shed. • Transfer of product to barges will be via covered conveyor.
Radiation exposure affecting terrestrial environment	• The RMP will define the requirements for periodic monitoring for both personal and environmental monitoring of radiation levels. This will include establishment prior to operations of background soil, sediment and airborne dust samples. • Products spills along the transport route or Derby Port will be subject to clean up such that residual levels of radiation are returned to established background levels. Material collected from any such spills or accidental release will be returned to the Mine Site for re-processing or disposal. • Background radiation levels in soil, sediments and airborne dust will be measured prior to construction commencing.

11.3.4 Predicted Outcome

The potential for impacts to terrestrial environmental quality as a result of transport, storage and export of product within the Derby Port Development Envelope is minimal. All transport of product is via covered road trains on sealed roads. These unload in an enclosed facility and product is loaded onto a conveyor within a bunded area. The product itself is granular, has a high specific gravity, and is not prone to producing dust, although some minor generation of dust may occur throughout the life of the project. The product is naturally occurring with a low level of radiation and is environmentally benign.

Soils at the site are not potentially ASS and the project will not result in any significant disturbance to soils or marine sediment within the Derby Port Development Envelope. The project will not result in loss of soil resources or associated environmental values.

Sheffield considers that the potential impacts of dust, radiation, and contaminated soils on terrestrial environmental quality will be able to be adequately managed such that the environmental objective (Section 11.3) will be met, and that the residual impacts are therefore acceptable.

11.4 HUMAN HEALTH

The EPA's objective in relation to human health is "*to ensure that human health is not adversely affected*".

11.4.1 Key Statutory Requirements, Environmental Policy and Guidance

Key statutory requirements, environmental policy and guidance for Human Health, in relation to the Derby Port Development Envelope are the same as for the Mine Site Development Envelope (Refer to Section 10.5.1), with the addition of the following considered in undertaking this impact assessment:

- A Guideline for Managing the Impacts of Dust and Associated Contaminants from Land Development Sites, Contaminated Sites Remediation and Other Related Activities (DEC 2011).
- EPA Guidance Statement No. 3, Separation Distances between Industrial and Sensitive Land Uses (EPA 2005).
- Air Quality Modelling Guidance Notes. Perth, WA. (DEC 2006).
- *National Environment Protection Measure for Ambient Air Quality 1994* as Amended 2003 (NEPC 2003).

11.4.2 Assessment of Potential Impact

This section discusses the potential for impact on human health in relation to the transport and export of materials through Derby Port. Bulk product received by the Derby Port; including transports within the Port, unloading of product for storage, storage of the product within a facility, and loading of product from the storage facility onto ships; has the potential to impact upon human health through exposure to radiation or increased exposure to dust particulates. Diesel particulates and vehicle emissions from haulage through the town of Derby also have the potential to impact on human health.

Naturally occurring radioactive materials (NORMs) contain the elements thorium and uranium which are associated with the heavy minerals, and in particular with monazite. As demonstrated in the mine residues characterisation (MBS 2016; Appendix 20), the uranium and thorium in monazite is tightly bound and unavailable environmentally, but is still subject to radioactive decay and emissions proportional to the concentration of monazite. In accordance with Australian Radiation Protection and Nuclear Safety Agency (ARPANSA 2005) and International Atomic Energy Agency Safety Guide RS-G-1.7 (IAEA 2004), materials containing NORMs are excluded from regulations and considered inherently safe if the specific activity concentrations are below 1 Bq/g. Concentrations of NORM up to 10 Bq/g are generally considered exempt in relation to transport restrictions due to the nature of the materials and form of radiation (alpha rather than gamma) primarily emitted (ARPANSA 2008).
The highest activity material exported is zircon concentrate (9.10 Bq/g) and therefore subject to decision by the Radiation Council and DMP may be exempt from transport restrictions. A Radiation Management Plan (RMP) and

Radiation Transport Management Plan (RTMP) will be prepared which will outline the management measures for worker and public radiation exposures are managed in accordance with the legislation.

Potential exposures and impacts include:

- **Radiation exposure affecting the health of transport drivers -** by external gamma radiation, radon and dust inhalation resulting from product handling and proximity to product while driving.
- **Radiation exposure affecting the health of workers -** by external gamma radiation, radon and dust inhalation resulting from product handling (unloading from trucks, storage and loading for shipping).
- **Radiation exposure affecting the health of members of the public -** through direct proximity (gamma radiation) to the products, or exposure to increased particulates through product transport through the town of Derby, product unloading, and product loading onto ships.
- **Dust emissions affecting the health of workers or members of the public** from:
  - Port product handling activities (e.g. loading and unloading vessels).
  - Emissions from the Derby Port Product Storage Facility (e.g. unloading from trucks).
  - Emissions associated with truck movements at Derby Port and through Derby townsite.
- **Diesel particulate and gaseous vehicle emissions exposure affecting the health of members of the public -** generated by transport vehicles travelling through Derby

Impacts from general dusts/particulates for the amenity related measures of TSP and dust deposition were discussed and addressed in Section 9.2; impacts from fine airborne particulates and inhalation of radionuclides in dust are discussed below.

11.4.2.1 Radiation Exposure Affecting the Health of Port Facility Workers

Potential exposures for Port workers were estimated based on:

- Exposure to external gamma irradiation by general proximity to the NORM materials (assumed 1 m distance).
- Inhalation of dust containing radionuclides (and hence exposure to otherwise short lived alpha particles).
- Possible inhalation of radon gas and radon decay products.
- Exposure of port workers was estimated based on handling of all export products by the same workers through a single export facility. Subsequent changes to allow export through two ports will affect exposure calculations. Exposures for individuals working at only one of these locations will be less than this estimate.

A high estimate of potential radon concentration is approximately 9.8 Bq/m^3, which is within typical background concentrations of radon in Australian homes of about 10 Bq/m^3 (Radiation Professionals 2016, Appendix 21).

Exposures for Derby Port workers to dust were calculated based on a high estimate of continual inhalation of 3 mg/m^3 airborne dust loadings at average total activity of all products (1.77 Bq/g). This assessment is also considered conservative as such dust levels are considered high for occupational levels, unlikely to be continual, and the majority of material which may generate dust (ilmenite) has low activity of 0.59 Bq/g (Radiation Professionals 2016; Appendix 21). Standard dust suppression measures of wetting/misting, covered conveyors, PPE and enclosed cabins will minimise exposure to dust for Port workers. Estimated exposures for Derby Port workers (Radiation Professionals 2016; Appendix 21) are summarised in Table 81 in comparison to the occupational exposure limit of 20 mSv/year (Regulation 16.18 *Mines Safety and Inspection Regulations 1995*).

Table 81: Summary of Estimated Derby Port Facility Workers Radiation Exposure

Exposure Pathway	Unit	Calculated Dose	Guideline Value	Percentage Guideline
External Gamma	mSv/year	1.24	20	6.2 %
Dust Inhalation	mSv/year	0.38	20	1.9 %
Total Exposure	mSv/year	**1.62**	**20**	**8.1 %**

Although radiation exposure to Derby Port facility workers is considered 'Almost Certain' by means of general proximity to products and hence exposure to gamma radiation within the Derby Port Development Envelope, the total exposure is considered 'Incidental'. The potential residual impact of radiation on the health of Derby Port workers, after implementation of the RMP and RTMP, is assessed as 'Medium'.

Impact	Consequence	Likelihood	Residual Impact
Radiation exposure affecting the health of Derby Port facility workers	Incidental	Almost Certain	Medium

11.4.2.2 Radiation Exposure Affecting the Health of Transport Workers

Exposure to dust inhalation and radon inhalation for drivers in sealed cabins and not normally involved in loading operations is considered very low, and was not assessed.

Although radiation exposure to transport workers is considered 'Almost Certain' when transporting higher activity loads such zircon concentrate, the total exposure is considered 'Incidental'. The potential residual impact of radiation on the health of transport workers, after implementation of the RTMP, is assessed as 'Medium'.

Impact	Consequence	Likelihood	Residual Impact
Radiation exposure affecting the health of transport workers	Incidental	Almost Certain	Medium

11.4.2.3 Radiation Exposure Affecting the Health of Members of the Public

Potential exposures for members of the public may occur through external gamma irradiation if in sufficiently close proximity to the products, or by inhalation of potential radionuclides within the dust.

Radon inhalation is not considered significant due to its rapid decay and dispersion. An estimate of exposure to gamma irradiation was based on walking within 10 m of the stockpiled products for five minutes every day (Radiation Professionals 2016, Appendix 21). Dust inhalation estimates were based on the same conservative airborne dust loadings as for workers (3 mg/m^3), but for only five minutes per day (very close proximity to loading operations would be required for this).

Potential exposure for members of the public on this conservative basis are summarised in summarised in Table 82) in comparison to the public exposure guideline of 1 mSv/year (ARPANSA 2002). Assessment of potential exposure to members of the public during routine trucking by brief periods of close proximity to loaded trucks was also made and assessed as being of very low potential exposure (Radiation Professionals 2016, Appendix 21).

Table 82: Summary of Estimated Public Radiation Exposure

Exposure Pathway	Unit	Calculated Dose	Guideline Value	Percentage Guideline
External Gamma	mSv/year	0.002	1	0.2 %
Dust Inhalation	mSv/year	0.006	1	0.6 %
Total Exposure	**mSv/year**	**0.008**	**1**	**0.8 %**

Although radiation exposure to members of the public is considered 'Possible' within the Derby Port Development Envelope and transport route to the Port, the total exposure is considered 'Incidental'. The potential residual impact of radiation on the health of members of the public, after implementation of the RMP, is assessed as 'Low'.

Impact	Consequence	Likelihood	Residual Impact
Radiation exposure affecting the health of members of the public	Incidental	Possible	Low

11.4.2.4 Dust Emissions Affecting the Health of Workers or Members of the Public

There is potential for an increase in airborne dust loadings from activities associated with the project, such as product transport and loading/unloading operations at the Derby Port.

Airborne dust particles less than 10 microns aerodynamic diameter (PM_{10}), and specifically those less than 2.5 microns ($PM_{2.5}$) are strongly linked to adverse human health effects such as cardiovascular disease and respiratory effects (NEPC 2014). There is potential for an increase in fine fraction (PM_{10} and $PM_{2.5}$) airborne particulate loadings from dust generation as a result of transport and loading/unloading operations at the Derby Port. Fine fraction airborne dust particulate matter as PM_{10} and $PM_{2.5}$ for the Derby Port Development Envelope were modelled by Atmospheric Solutions (2016) along the transport route (Loch Street) and Port area to examine the potential impact of fine fraction airborne particulate matter on Derby workers and residents' health.

Modelled ambient particulate levels and dust deposition for the Derby Port Development Envelope and the transport route are shown in Figure 52 to Figure 54. Both PM_{10} and $PM_{2.5}$ were modelled for a 24 hour period. Comparative ambient air quality targets for PM_{10} and $PM_{2.5}$ are 50 $\mu g/m^3$ and 25 $\mu g/m^3$ respectively (NEPC 2003).

Modelling showed that PM_{10} concentrations ranged from an ambient level of 20 $\mu g/m^3$ to a maximum of 22 $\mu g/m^3$ along the transport route and within the Derby townsite (Figure 52). A concentration of 50 $\mu g/m^3$ PM_{10} was modelled at the Port boundary, however there are no sensitive receptors/residents located in this area.

Modelled $PM_{2.5}$ concentrations ranged from the ambient level, 7 $\mu g/m^3$ to a maximum of 8 $\mu g/m^3$ along the transport route and within the Derby townsite (Figure 54). A concentration of 15 $\mu g/m^3$ $PM_{2.5}$ was modelled at the Port boundary, however there are no sensitive receptors located in this area.

Results of air emissions inferred from modelling are summarised in Table 83, with predicted particulate emissions for PM_{10} and $PM_{2.5}$ below the limits specified in the National Environment Protection Measure for Ambient Air Quality (NEPM AAQ).

Table 83: Modelled Fine Fraction Dust Emissions for Port and Transport Activities

Particulate	Unit of Measure	Guideline Limit	Modelled Maximum Project Level		
			Port Boundary	Transport Route	Derby Townsite
Ambient PM_{10}	$\mu g/m^3$ (24 hr average, maximum level)	50[1]	50	22	22
Ambient $PM_{2.5}$	$\mu g/m^3$ (24 hr average)	25[2]	15	8	8

[1] Unit as specified in the NEPM AAQ Limit for the particulate; [2] NEPM AAQ Advisory Standard.

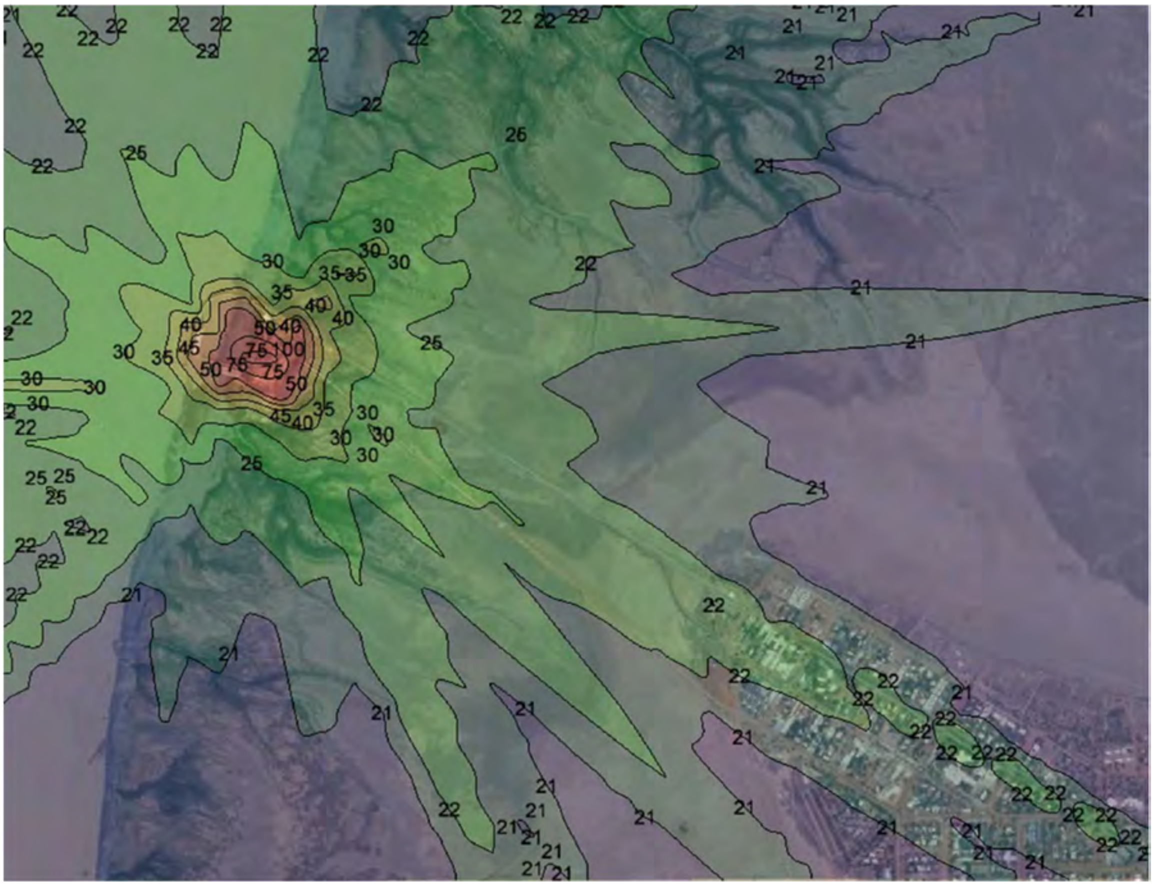


Figure 52: Modelled Ambient PM10 (24 hr average, maximum) Derby Port and Transport Route

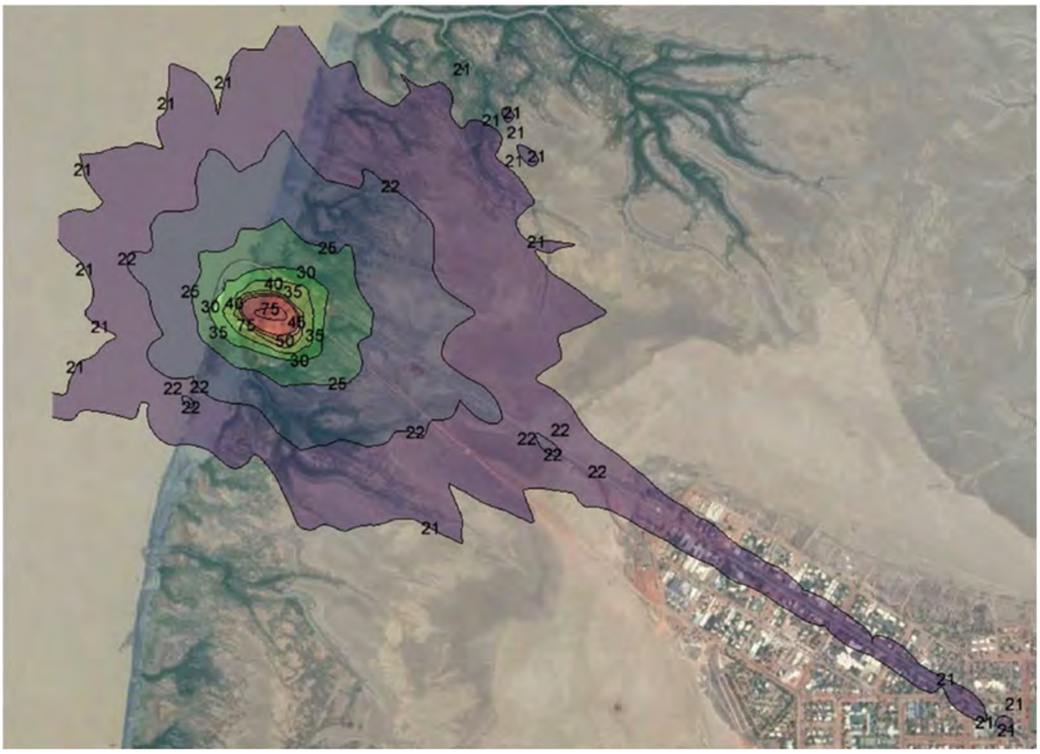


Figure 53: Modelled Ambient PM10 (24 hr average, 6th highest in order) Derby Port and Transport Route

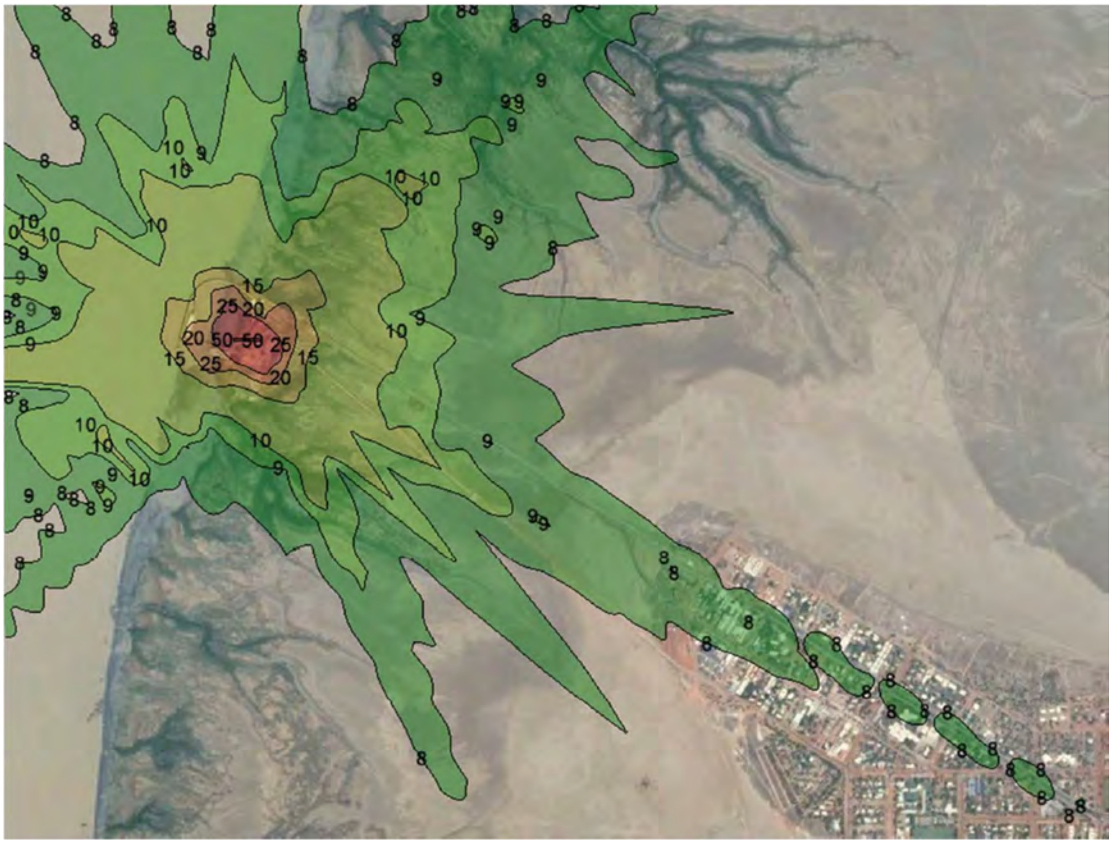


Figure 54: Modelled Ambient PM2.5 (24 hr average) Derby Port and Transport Route

Dust generation during construction of the Product Storage Facility is expected to be short-term and localised. As the site is already levelled, very minimal disturbance of soils is expected other than for installation of services and minor foundation works as required.

Dust emissions during storage and transfer of mineral sands products are expected to be incidental. The export products have limited potential for dust generation as they are granular, do not contain fines, and have high specific gravities. Mineral sands products will be unloaded and stored within the Product Storage Facility, which will be negatively pressured to further minimise dust emissions and also wetted/misted if required based on observations and results of monitoring. All mineral sands products are highly insoluble and do not contain leachable contaminants such as heavy metals or other environmental toxicants.

There will be an average of 20 road train movements (10 return trips) along the transport route per 24 hour period during the operational phase of the project. Other than the Site Access Road within the Mine Site Development Envelope, the transportation route is entirely on sealed roads using covered or bagged product transport, vastly decreasing the amount of dust generated when compared to unsealed roads. Products will be stored in a purpose-built facility with dust suppression including an enclosed unloading area to ensure products are contained within the facility during unloading activities. Transfer of bulk product to transhipment vessels (barges) for loading will be via a covered conveyor. Loading and handling of products at the Port and within the Product Storage Facility will be subject to positional environmental dust monitoring as part of an integrated environmental management plan (EMP) for the Port and Mine Site.

Based on the results of the modelling, product properties and management measures, bulk product transport and port activities, isolated and infrequent acute impacts may occur to the health of members of the public, but this is very 'Unlikely' to occur. However, it is 'Possible' that isolated and infrequent acute impacts may occur to the health of workers. The potential residual impact of dust emissions on the health of workers and members of the public, after implementation of management measures, is assessed as 'Low'.

Impact	Consequence	Likelihood	Residual Impact
Dust emissions affecting the health of workers	Incidental	Possible	Low
Dust emissions affecting health of members of the public	Minor	Unlikely	Low

11.4.2.5 Diesel Particulate and Gaseous Vehicle Emissions Exposure Affecting the Health of Members of the Public

Diesel particulate matter (DPM) was classified as a definite human carcinogen by the International Agency for Research on Cancer (IARC) in June 2012 (IARC 2012). Diesel particulate consists of very fine particles of elemental carbon which have the ability to absorb significant quantities of various semi-volatile hydrocarbons (many classified toxic and carcinogenic such as polyaromatic hydrocarbons [PAHs]) originating from unburnt fuel and lubricating oils during the combustion cycle. The very small particle size of DPM (typically less than 1 micron aerodynamic diameter) gives it the potential to reach deep into the lung. The classification of DPM as a definite carcinogen was the progression of studies over 30 years (AIOH 2013, IARC 2014), based primarily on occupational DPM exposure from older diesel engines (pre-2004), and adjusting for a latency (delay) period between exposure and cancer of 30 to 40 years.

During this period of time however, advances in diesel engine technology and introduction of emissions laws in Europe and the US have resulted in significant reductions in emitted levels of DPM and associated compounds such as PAHs. Percentage reductions in DPM measured in elemental carbon (99%) and PAHs (79%) in 2007 model engines versus 2004 technology engines indicate the degree to which these measures have been effective (IARC 2014) and hence reduced the risk of exposure leading to health effects. Estimates in Australia range from 80 to 90% reduction in DPM with modern diesel engines such as Euro V (DIRD 2016). Studies in California, one of the first jurisdictions to require diesel emissions controls on vehicles, have shown a threefold decrease in DPM to below 0.6 $\mu g/m^3$ ambient background concentrations despite a significant 80% increase in vehicle traffic since 1990 (Propper *et. al.* 2015). The currently recommended occupational health guideline for DPM in WA is 100 µg/m³ (AIOH 2013). In addition, with changes in fuels the chemical emission profile is now significantly different to past DPM exposures upon which cancer epidemiology studies were based – namely reductions in carcinogens such as PAHs as well as general DPM. Health effects of gaseous vehicle emissions (CO, NO_x and SO_x) were previously discussed in Section 10.4.2 – it is noted that vehicle emissions and fuel standards have also led to significant reductions in emissions for these species.

Based on the additional 10 return trip truck movements per day along Loch Street (an approximate 2.4% increase on 2013/14 levels) for modern diesel trucks generally operating at optimum temperatures, any increases in DPM and gaseous vehicle emissions are not likely to be measurable. Isolated and infrequent acute impacts to the health of members of the public is considered ‘Unlikely’. The potential residual impact of diesel particulate and gaseous vehicle emissions on the health of members of the public, after implementation of management measures, is assessed as ‘Low’.

Impact	Consequence	Likelihood	Residual Impact
Diesel particulate and gaseous vehicle emissions exposure affecting the health of members of the public	Minor	Unlikely	Low

11.4.3 Management Measures

A summary of key measures to address potential impacts on human health from radiation is shown in Table 84. Further detail regarding the assessment and management measures for the protection of human health are detailed in Appendix 21 (Radiation Professionals, 2016).

No further management measures are considered necessary.

Table 84: Proposed Management Measures for Human Health (Derby Port and Transport Route)

Potential Impact Requiring Management	Measure
Radiation exposure affecting the health of Derby Port employees or members of the public	• Provision and maintenance of equipment and facilities for controlling radiation sources, including housekeeping, dust suppression and surface contamination control to maintain a duty of care to employees and the public • The facility will be registered under the RSA with the Radiological Council and DMP and Sheffield will appoint a Radiation Safety Officer (RSO) to implement a Radiation Management Plan (RMP) on behalf of Sheffield. • A radiation monitoring program will be implemented at the Port in consultation with the Radiological Council and DMP which will define the requirements of monitoring for both personal (and environmental radiation levels. This may include background, operational and post-closure radiation monitoring for personal exposure of Port workers as well as soil, sediment and air samples.
Radiation exposure affecting the health of transport workers or members of the public	• The product transport activities from the Mine Site to Derby Port will be registered with the Radiological Council and Sheffield will appoint a Radiation Safety Officer (RSO) to implement a Radiation Transport Management Plan (RTMP). • Personal dose monitoring for transport workers (in particular drivers) will be undertaken in accordance with a radiation transport management plan (RTMP) endorsed by the Radiological Council.

Potential Impact Requiring Management	Measure
	• Radiation monitoring of transport trucks leaving the Mine Site and Port facility for external radiation levels using hand held gamma radiation and alpha radiation wipe tests will be conducted in accordance with the RTMP. • Products spills along the transport route or Derby Port will be cleaned up such that residual levels of radiation are returned to established background levels. Material collected from any such spills or accidental release will be returned to the Mine Site for re-processing or disposal.
Dust emissions affecting the health of workers or members of the public.	• Bulk Product will be transported in sealed containers. • Bulk product will be stored in a purpose built Product Storage Facility with enclosed drive through unloading area to minimise dust emissions and then loaded onto transhipment vessels using a closed conveyor and/or sealed bags. • Dust monitoring will be conducted in accordance with DMP CONTAM and DER requirements.
Diesel particulates and gaseous vehicle emissions affecting the health of members of the public	• Road trains used for the project will employ modern Euro V (post 2009) diesel engines which are maintained according to a regular maintenance schedule.

11.4.4 Predicted Outcome

Radiation can be effectively managed under the *Mines Safety and Inspection Act 1995* and *Radiation Safety Act 1975* jointly by DMP and Radiological Council of WA.

The predicted dose to Derby Port workers was estimated to be a maximum of 1.62 mSv/year which is well below the dose rate limit for radiation workers of 20 mSv/year. The predicted dose to transport works was conservatively estimated to be less than 0.5 mSv/year which is below the public limit of 1 mSv/year. The predicted dose to a member of the public was conservatively estimated to be 0.008 mSv/year which is well below the public limit of 1 mSv/year.

All activities for transport and handling of product at the Derby Port Facility associated with the project will be undertaken in accordance with the *Radiation Safety Act 1975* and *Radiation Safety (Transport of Radioactive Substances) Regulations 2012*. The facility will be registered under the RSA and the proponent will engage a Radiation Safety Officer on the implementation of a RMP and a RTMP, to implement periodic personal and environmental monitoring of radiation levels for formal reporting to the Radiological Council and DMP. Implementation of these arrangements will ensure that any potential radiation doses to workers, the public and the environment will be monitored, controlled and minimised to ensure that all legal requirements are met and that radiation doses are below regulatory limits.

Sheffield considers that the potential impacts of radiation, DPM, and gaseous vehicle emissions to human health will be able to be adequately managed such that the objective (Section 11.4) will be met, and that the residual impacts are therefore acceptable.

11.5 HYDROLOGICAL PROCESSES

The EPA's objective in relation to hydrological processes is "*to maintain the hydrological regimes of groundwater and surface water so that existing and potential uses, including ecosystem maintenance, are protected*".

11.5.1 Key Statutory Requirements, Environmental Policy and Guidance

Relevant statutory requirements, environmental policies and guidance for hydrological processes at the port are similar to those of the Mine Site Development Envelope, as detailed in Section 8.3.1.

11.5.2 Assessment of Potential Impacts

King Sound is subject to extremely high tides as detailed under Section 4.3.11.2. The port area has been constructed using imported fill and has been raised above the high tide level. The proposed Product Export Facility will not change or impact current hydrological processes at the port. Key infrastructure, notably the storage shed, will be constructed above the highest recorded tide level and will not be prone to flooding.

No groundwater will be abstracted for operation of the export facility and all water needs will be met by the town water scheme using existing infrastructure. No hydrological impacts are therefore expected within the Port Development Envelope.

11.5.3 Management Measures

No management measures are required for hydrological processes at the port.

11.5.4 Predicted Outcome

As the project will not impact existing hydrological processes within the Port Development Envelope, Sheffield considers that the EPA objective for hydrological processes will be met.

12. ENVIRONMENTAL IMPACT ASSESSMENT - INTEGRATING FACTOR - REHABILITATION AND DECOMMISSIONING

The EPA's objective for rehabilitation and decommissioning is "*to ensure that premises are decommissioned and rehabilitated in an ecologically sustainable manner*".

12.1 KEY STATUTORY REQUIREMENTS, ENVIRONMENTAL POLICY AND GUIDANCE

Rehabilitation and decommissioning planning are governed under Commonwealth and State legislation:

- *Mine Safety and Inspection Act 1994* and Regulations 1995 (WA).
- *Mining Act 1978 (WA)*.
- *Contaminated Sites Act 2003 (WA)*.
- *Radiation Safety Act 1975 (WA)*.

In addition to Commonwealth and State legislation, the following policy and guidance statements were considered in the impact assessment for rehabilitation and decommissioning:

- Thunderbird Mineral Sands Project Environmental Scoping Document.
- Guidelines for Preparing Mine Closure Plans (DMP and EPA 2015).
- Principles of the Strategic Framework for Mine Closure (ANZMEC and MCA 2000).
- Guidance Statement No.6 Rehabilitation of Terrestrial Ecosystems (EPA 2006a).
- Environmental Protection Bulletin No. 19 EPA involvement in Mine Closure (EPA 2015f)
- Radiation Protection Series Publication No. 9 – Radiation Protection and Radioactive Waste Management in Mining and Mineral Processing (ARPANSA 2005).

12.2 ASSESSMENT OF POTENTIAL IMPACT

To prevent and minimise adverse long term environmental, social and economic impacts associated with a mine, planning for mine rehabilitation and decommissioning needs to be included into project design and costing and be conducted as a Life of Mine process. The Australian mining industry has a well-established commitment to ensure that any closed mining operations are:

- **Safe** - no obvious risk to the public remains at the project.
- **Stable -** in terms of stability against landslips and stability to reduce erosion to a practicable minimum.
- **Non-polluting** - contaminant seepage into groundwater and/or wind erosion from facilities.
- **Empathetic to the surrounding landscape** - aesthetically pleasing, landforms to blend in with the natural landscape.
- **Minimal (preferably no) ongoing maintenance** - allowing for a period of post-decommissioning care and maintenance.
- **Economic to construct** - reducing landform management costs whilst meeting corporate and regulatory standards.

A preliminary Mine Closure Plan (MCP) has been developed by MBS Environmental to ensure that these targets can be achieved (MBS 2016d; Appendix 4).

This includes an assessment of potential impacts relevant to closure and rehabilitation of the project. The most significant potential impacts include:

- Closure obligations prove impractical, and cannot be met.
- Premature closure of the mine, potentially leading to exposed tailings material in the TSF and mine pits that remains unrehabilitated.
- Injury caused to a member of the public, from accessing unsafe or unstable decommissioned infrastructure, landforms, or voids.
- Stormwater ponding or runoff on any remaining mine waste landforms such as the TSF or mineral deposit area, leading to instability and/or erosion and sediment transport.
- Insufficient mine waste material to backfill final mine void resulting in the potential formation of a pit lake with increasing salinity trends.
- Underestimation of material swell factor resulting in excessive consolidation of backfilled material within mine pits and formation of local depressions and seasonal surface water ponding.
- Failure to stockpile sufficient topsoil and growth medium to support revegetation objectives.
- A legacy of contaminated sites, accumulated from spills or leaks over the life of mine.

The preliminary MCP addresses these potential impacts by establishing the planning, investigations and closure and rehabilitation procedures needed to achieve the targets detailed above.

The geochemical assessment of general mine waste and process residues which will be backfilled to the mine void (4.2.7) indicated no significant potential impacts to the environment relevant to rehabilitation and de-commissioning other than those listed above. Any risk in relation to exposure of potentially acid sulfate soils for material late in the project life at extreme depth below the natural groundwater table will be managed during the operational phase with the implementation of an Acid Sulfate Soil Management Plan. Post closure recovery of the groundwater table to pre-mining levels will then entirely cover any such material and remove any potential for ongoing acid generation by exposure of sulfides to oxygen.

12.3 MANAGEMENT MEASURES

The preliminary MCP has been developed in order to address potential impacts related to rehabilitation and closure (Appendix 4). The preliminary MCP details the following:

- Closure obligations and commitments.
- Stakeholder identification and engagement.
- Post mining land used and closure objectives.
- Development of completion criteria.
- Closure data.
- Identification and management of closure risks.
- Closure implementation (including the development of closure domains).
- Closure monitoring and maintenance.
- Financial provision for closure.

Preparation of the preliminary MCP at this stage of the project will ensure that potential impacts resulting from poor rehabilitation and closure practices are negated through effective planning.

Management measures required for rehabilitation and closure of each of the domains and features are given within the preliminary MCP. These measures will be further developed through preparation of a detailed MCP following receipt of project approvals. As per the preliminary MCP, the detailed MCP will be developed in accordance with the revised joint DMP and EPA Guidelines for Preparing Mine Closure Plans (2015). This will in turn be revised and updated every three years as required by the guidelines or at such other time as required by DMP.

12.4 PREDICTED OUTCOME

Through the development of the preliminary and detailed MCP, Sheffield considers that potential residual impacts during decommissioning and closure on the environment will be able to be adequately managed such that the EPA's environmental objective for rehabilitation and closure (Section 12) will be met, and that the residual impacts are therefore acceptable.

13. ENVIRONMENTAL IMPACT ASSESSMENT - MATTERS OF NATIONAL ENVIRONMENTAL SIGNIFICANCE

13.1 INTRODUCTION

The project was referred to the (then) Commonwealth Department of the Environment on 8 February 2016 under the *EPBC Act* and was deemed to be a 'Controlled Action' on 7 April 2016 in respect to impacts on listed threatened species, specifically the Greater Bilby (*Macrotis lagotis*).

During development of the Environmental Scoping Document, the (then) Department of the Environment specifically required Sheffield to consider impacts of the project within the Mine Site Development Envelope on a number of other listed threatened species, specifically:

- Dwarf Sawfish (*Pristis clavata*) – listed as Vulnerable under the *EPBC Act.*
- Green Sawfish (*Pristis zijsron*) – listed as Vulnerable under the *EPBC Act*.
- Largetooth Sawfish (*Pristis pristis*) – listed as Vulnerable under the *EPBC Act*.
- Northern River Shark (*Glyphis garricki*) – listed as Endangered under the *EPBC Act*.

This request also included one species for the Derby Port Development Envelope:

- Humpback Whale (*Megaptera novaeangliae*) – listed as Vulnerable under the *EPBC Act*.

The Environmental Scoping Document requires consideration of the impacts on these species within the Marine Fauna Factor, which is not considered to be a Key Factor for the project.

Potential impacts on Dwarf, Green, and Largetooth Sawfish, and the Northern River Shark within the Mine Site Development Envelope relate to potential changes to hydrological regimes in watercourses as a result of groundwater abstraction required for the project. This is discussed in Section 11.2.2.3. Fraser River South has been identified as the only inland habitat associated with the project where juvenile Largetooth Sawfish may occur during the wet season. This watercourse is not considered potential habitat for other Sawfish species or the Northern River Shark (DoE 2015b). The project is expected to result in no discernible loss of habitat for these species, loss of individuals, or interruption to breeding patterns or behaviour. Management measures proposed in Section 11.2.3 are sufficient to manage potential impacts, and no additional management measures are proposed.

Potential impacts on the Humpback Whale are primarily in relation to additional shipping movements from Derby Port, which is assessed in Section 11.2.2.4. As Derby Port is already an existing port, the increase in transhipment vessel and tug movements is expected to present a limited additional impact. Management measures proposed in Section 11.2.3 are sufficient to manage potential impacts to Humpback Whales, and no additional management measures are proposed.

13.2 ASSESSMENT OF POTENTIAL IMPACTS – GREATER BILBY

The Greater Bilby (*Macrotis lagotis*) is listed as Vulnerable under the *EPBC Act* and Schedule 3 under the *WC Act 1950*. More information about the species and its presence within the Mine Site Development Envelope is provided in Section 4.2.9.3.

The potential impacts of the project on the Greater Bilby are presented below. These have been ranked in order of the highest to lowest potential impact:

- **Fragmentation of habitat resulting in displacement**.
- **Clearing activities causing injury or death**.

- **Vehicle strike causing injury or death**.
- **Increased predation causing injury or death**.
- **Altered fire regime causing injury or death or loss of habitat**.
- **Light and noise pollution disrupting nocturnal activities**.
- **Entrapment leading to injury or death**

Other potential impacts were screened out from further assessment (Section 7.4) as they were either assessed as not likely to occur or were unlikely to have any discernible consequence on any factor different to background levels:

Stressor	Justification for Exclusion
Radiation exposure to native fauna	The vast majority (98%) of all waste streams is from ilmenite processing or initially rejected sand/slimes material with low activity (0.39 Bq/g, see Appendix 21). Material with activity less than 1 Bq/g based on composition of Sheffield waste materials did not trigger the Tier 1 Environmental screening criteria of 10 µGy/h using the ERICA software assessment (ARPANSA 2015) for terrestrial flora. Sheffield commit to mixing and co-disposal of wastes to <1 Bq/g (combined activity c.a. 0.74 Bq/g). Backfill areas will be monitored to ensure radiation levels are within environmental screening criteria (10 µGy/h) or established pre-mining background levels. The inherent use of wet slurries for transport of mine waste back to the void minimises potential for dust emissions of higher activity material.

The assessed likelihood, consequence and residual impact (as per Section 7.3), is provided below for each potential impact.

Over and above this impact assessment, Sheffield has developed an Environmental Management Plan for the Greater Bilby which is attached as Appendix 23. This plan details the potential impacts upon the Greater Bilby and management measures that will be implemented during the duration of the project. The data that is collected will be freely available to the community and scientific institutions undertaking research on the Greater Bilby.

13.2.1 Fragmentation of Habitat Resulting in Displacement

Fragmentation of fauna habitat from land clearing may lead to loss of individuals through competition as affected individuals are required to relocate and compete. Approximately 1,632.9 ha of potential Greater Bilby habitat will be temporarily lost over the timeframe of the project; however due to the progressive nature of mineral sands mining the loss of this habitat will occur over a 40+ year time frame thus greatly reducing the impacts to the species in the area.

In addition the mining void created will be backfilled and rehabilitated as the project proceeds forward. This will provide new prospective habitat for the species to colonise.

Rehabilitation will aim at re-creating the Greater Bilby's preferred habitat and as a minimum, will be consistent with the condition of the vegetation in the greater area surrounding the project. This form of rehabilitation will mean that as habitat is removed, new habitats will be created for the Bilby to recolonise.

Minor, localised loss and fragmentation of Greater Bilby fauna habitat is 'Almost Certain', however the overall habitat in the area will remain intact. The potential impact from the fragmentation of habitat on the Greater Bilby is assessed as 'Medium'.

Impact	Consequence	Likelihood	Residual Impact
Fragmentation of habitat resulting in displacement	Minor	Almost Certain	Medium

13.2.2 Clearing Activities Causing Injury or Death

Clearing activities can result in the injury and/or death of Greater Bilbies who may be crushed and or injured by heavy machinery whilst they are resting in their underground burrows during the daylight hours. While pre-clearance surveys will be undertaken, the Greater Bilby's nocturnal and burrowing behaviours make them difficult to locate and remove to safety prior to clearing.

Although the death of animals is 'Almost Certain' to occur over the life of mine, this will not impact on the survival of the local population. The potential residual impact from clearing activities on Greater Bilbies is assessed as 'Medium'.

Impact	Consequence	Likelihood	Residual Impact
Clearing activities resulting in injury or death	Incidental	Almost Certain	Medium

13.2.3 Vehicle Strike Causing Injury or Death

Greater Bilby individuals within the Mine Site Development Envelope will be at risk of injury and/or death due to vehicle strike. This would be more likely along the Site Access Road and the road connecting the accommodation village and operational areas, particularly during the night when the Greater Bilby is most active. Vehicle strike from construction machinery is less likely than from vehicles on roads, as the Greater Bilby would be able to move away and avoid direct impact.

Although the death of several animals is considered to be 'Almost Certain' over the life of mine, this will not impact on the survival of the local population. The potential residual impact from vehicle strike on Greater Bilbies is assessed as 'Medium'.

Impact	Consequence	Likelihood	Residual Impact
Vehicle strike causing injury or death	Incidental	Almost Certain	Medium

13.2.4 Increased Predation Causing Injury or Death

Potential increase in pest species (populations and number of species) through establishment of domestic waste disposal and permanent water storage facilities may result in increased predation on the Greater Bilby by cats and/or dogs.

Although the death of several animals is 'Likely' to occur over the life of mine, this will not impact on the viability or abundance of the local population. The potential residual impact from increased predation on the Greater Bilby is assessed as 'Medium'.

Impact	Consequence	Likelihood	Residual Impact
Increased predation causing injury or death	Minor	Likely	Medium

13.2.5 Altered Fire Regimes Causing Injury or Death or Loss of Habitat

The Kimberley region is subject to frequent burning, which has increased in intensity in recent years; either as a result of natural or deliberate events (Section 4.2.11). Controlled burning conducted as part of pastoral activities will not be conducted on the same frequency or extent within the Mine Site Development Envelope as a result of implementation of the project. Due to the increased presence of people and machinery in the area there is however an increased risk of accidental fires, which could affect fauna and habitat on a local and regional scale. The project site induction will include information on the prevention and management of accidental fires. Should a fire occur, Greater Bilbies are likely to move away from the fire.

Vehicles will not be permitted to leave access tracks or cleared areas. Firefighting equipment will be maintained within light vehicles, earth moving equipment and buildings. Larger scale firefighting response will be provided as part of the projects Emergency Response Plan. Fire breaks will be installed at key locations to minimise risk to people and infrastructure. Lightning protection will be installed within the processing plant to minimise risk of damage to key infrastructure. Implementation of a Hot Work permit system will minimise the risk of accidental fire due to project activities. The result of these changes is likely to be a reduction in widespread cool, controlled burns across the Mine Site Development Envelope and an increase risk of uncontrolled, hot burns for small areas within the Mine Site Development Envelope.

It is ‘Unlikely’ that an accidental fire will occur, and any loss of habitat from fire is likely to be localised and short-term. The potential residual impact of altered fire risk on Greater Bilbies, after implementation of management measures, is assessed as ‘Low’.

Impact	Consequence	Likelihood	Residual Impact
Increased fire risk causing injury or death	Incidental	Unlikely	Low

13.2.6 Light and Noise Pollution Disrupting Nocturnal Activities

Development of the project may result in an increase in light and noise pollution which could potentially result in changes to the Greater Bilbies nocturnal activities. However, the amount of natural habitat surrounding the project means that impacts are likely to be minimal, and affected individuals are likely to move away from noise or light sources. Management measures to limit the impact of noise and light on fauna will be implemented (Section 8.2.3).

Light and noise are considered a ‘Likely’ impact on the Greater Bilby, however no mortality of individuals is expected as the Bilbies will move to alternate habitats and/or burrows to avoid this impact. The potential residual impact of light and noise on the Greater Bilby is assessed as ‘Low’.

Impact	Consequence	Likelihood	Residual Impact
Light and noise pollution disrupting nocturnal activities	Incidental	Likely	Low

13.2.7 Entrapment Causing Injury or Death

Trenches, excavations, and water storage structures often have steep, slippery sides which prevent fauna, which may fall into them, from escaping. Fauna may also be attracted to waste storage bins or domestic waste facilities, and become trapped. Entrapment may lead to fauna injury or death from starvation, dehydration, drowning, or injury. Fauna egress mats, fencing and visual inspections will be implemented to reduce the potential impact to fauna.

Mortality of Greater Bilby individuals is considered 'Unlikely' to occur, and will not result in effects on population viability or species diversity. The potential residual impact of entrapment on the Greater Bilby is assessed as 'Low'.

Impact	Consequence	Likelihood	Residual Impact
Light and noise pollution disrupting nocturnal activities	Incidental	Unlikely	Low

13.3 FEASIBLE ALTERNATIVES

Direct loss of habitat as a result of land clearing for the mine development and injury or mortality due to vehicle strikes represents the greatest potential impacts upon the Greater Bilby.

Considerations of any alternatives to the direct impact clearing of the pit area habitats are constrained by the fact that the deposit area cannot be avoided or substantially reduced in size due to the fact that it contains the mineral resources central to the economic viability of the project.

Alternatives to the location of the Site Access Road were considered, however based on the fact that a current road already exists where the Site Access Road will be located, it was determined that this option would have the least impact upon the Greater Bilby, since it requires the least additional or cumulative disturbance to potential habitat and those individuals established in the area are accustomed to vehicle traffic.

Sheffield has considered the management of direct and indirect impacts on the Greater Bilby and its habitat in order to avoid, minimise, reduce or eliminate potential adverse effects on the Greater Bilby population through the careful development and design of the project infrastructure to avoid areas where significant evidence of Greater Bilby presence was observed where possible.

13.4 MANAGEMENT AND MITIGATION MEASURES

A summary of key measures to address potential impacts on the Greater Bilby are shown in Table 85.

Table 85: Specific Management Measures for the Greater Bilby

Potential Impact Requiring Management	Measure
Fragmentation of habitat resulting in displacement	• Clearing activities will be managed to ensure clearing is strictly limited to that necessary for operations. • Land clearing will be undertaking progressively with the amount of active disturbance minimised. • Disturbed areas will be rehabilitated as they become available. • Topsoil and vegetation will be respread over rehabilitated areas to act as a seed source and mulch to protect the soil from erosion and provide habitat for fauna.

Potential Impact Requiring Management	Measure
Clearing activities causing injury or death	• Pre-clearance surveys will be undertaken no more than one month ahead of planned land clearing. As Bilbies are highly mobile, utilisation of burrows can vary nightly. To ensure pre-clearance surveys are accurate and information is current, the following protocols will be implemented: – The time between pre-clearance surveys and clearing will be minimised a far as practicable. – Locations of burrows previously identified in the clearing area (both active and non-active burrows) will be inspected. The areas surrounding these locations will also be searched to identify any new burrows in the vicinity. – All burrows present will be assessed to determine if they were recently active (evidenced by 'fresh' spoil, tracks, diggings and scats). – Motion sensor cameras will be used to monitor active Bilby burrows and confirm if Bilbies are present immediately prior to clearing. • In the week preceding entry of large scale mechanised equipment used for land clearing, active Bilby burrows will be identified during ore-clearance surveys. Those not containing young will be collapsed after either capture or removal of the animal to minimise potential for ongoing use prior to land clearing. • A Greater Bilby capture and relocation (translocation) program will be developed. If pre-clearance surveys indicate active burrows occur within the area to be cleared, then the Greater Bilby translocation program will be implemented by a suitably qualified environmental professional. • • A suitably qualified person (fauna spotter) will be on site during land clearing. The fauna spotter will meet the following requirements: – Have appropriate training in fauna handling techniques. – Will hold a permit to handle and move significant fauna under Regulation 15 of the Wildlife Conservation Act 1950. – Have suitable equipment to administer emergency care to injured and or displaced fauna. – Have access to a care facility that can used to rehabilitate injured fauna. Sheffield has established relationships with wildlife rehabilitation care organisations in Broome, who can provide care if required.
Vehicle strike causing injury or death	• Speed limits will be implemented for operational areas and the Site Access Road. • Personnel will be required to adhere to speed limits and drive to road/weather conditions to minimise risks of fauna injuries or death due to vehicle traffic • The Site Access Road will be constructed with a 5 m buffer of cleared area on each side with topsoil stockpiles located up to 20 m away from the trafficable surface. • Travel between dusk and dawn on the Site Access Road and village access road will be limited to essential travel with driving speed limits set to reduce the potential for road strikes. • The site induction program will provide information on the Greater Bilby and the importance of minimising impacts on the species.

Potential Impact Requiring Management	Measure
Increased predation causing injury or death	• Sheffield will undertake pest animal control within the Mine Site Development Envelope in co-operation with regional control programs. • Domestic waste facilities will be fenced and putrescible wastes will be regularly covered. • Borrow pits will be designed and constructed to minimise permanent water ponding after rehabilitation.
Altered fire regime causing injury or death or loss of habitat	• Firefighting equipment will be located on site and emergency personnel will be trained in fire response • Lightning protection equipment will be installed as part of project design where necessary. • Vehicles will not be permitted to leave access tracks or cleared areas. • A Hot Work Permit system will be developed and implemented. • All machinery and vehicles undertaking clearing activities will be fitted with firefighting equipment. • Sheffield will work with the pastoralist, Traditional Owners and DFES to undertake prescribed burns and install and maintain firebreaks if required so that potential environmental damage from extreme and out of control wildfires is minimised and infrastructure and the community are protected throughout the life of the project. • The project site induction will include information on the prevention and management of fires.
Light and noise pollution disrupting nocturnal activities	• Travel between dusk and dawn on the Site Access Road and village assess road will be limited to essential travel. • Lights will be strategically placed and designed to shine towards plant operations and minimise light spill to the environment. • Equipment design will specify compliance with Australian Standard noise limits.
Entrapment leading to injury or death	• Artificial water sources will have egress points installed. • Open holes, trenches, landfill, and any water holding facilities will be inspected regularly for fauna. • Domestic waste facilities will be fenced and putrescible wastes will be regularly covered.
Radiation exposure resulting in loss or reduced health and condition of Greater Bilbies	• Rehabilitated areas will be monitored to ensure radiation levels are consistent with measured pre-mining background levels.

13.5 DOEE SIGNIFICANCE ASSESSMENT

The *EPBC Act* provides guidelines for self-assessment of whether an action is likely to have a significant impact on a matter of national environmental significance (DoE, 2013). While these guidelines are aimed at determining whether a project should be referred to DoEE to determine if it is a Controlled Action, the criteria are also useful for consideration as part of the impact assessment process. Four factors are routinely considered as part of this assessment. These factors were considered as part of the EPBC referral with the assessment documented in Table 86.

When addressing potential impacts on listed threatened species that are classified as Vulnerable, such as the Greater Bilby, DoEE provide more specific impact criteria to be addressed. An assessment against these criteria is provided in Table 87.

Table 86: Consideration of Significant Impact on Matters of National Environmental Significance

Significance Test Item	Assessment for Thunderbird Mineral Sands Project
Are there matters of National Environmental Significance located in the area of proposed action?	The Greater Bilby is known to be present within the Mine Site Development Envelope and surrounding areas. Presence was identified by observation of scats, diggings, inactive and active borrows during project specific baseline fauna studies. DNA examination of scats identified at least 9 individuals present within the survey area. No other matters of national environmental significance are known to be within or adjacent to the proposed project area that could be directly or indirectly impacted by implementing the action.
Is there potential for impacts (direct and indirect) on matters of National Environmental Significance?	The potential impacts (direct and indirect) on matters of national environmental significance are discussed in greater detail in Section 13.2. Impacts include: • Loss and or fragmentation of habitat resulting in displacement. • Clearing activities causing injury or death of individual animals. • Vehicle strike causing injury or death of individual animals. • Increased predation causing injury or death of individual animals. • Altered fire regimes causing injury or death or loss of habitat. • Light and noise pollution disrupting nocturnal activities. • Entrapment causing injury or death of individual animals.
Are there any proposed measures to avoid, reduce impacts?	Project design has considered environmental factors including matters of National Environmental Significance. This has included site layout, building placement, infrastructure design and operational rules. The hierarchy of avoid, minimise, mitigate has been considered and implemented. Avoidance of habitat of the Greater Bilby is not possible as the species is considered non-selective and may use multiple areas within the Mine Site Development Envelope. As such avoidance of Greater Bilby habitat within the deposit area cannot be achieved or substantially reduced in size due to the fact that it contains the mineral resource which is central to the economic viability of the project. The amount of land clearing has been minimised to reduce the direct impact. Progressive clearing for mining and rehabilitation of completed mined areas in compliance with an agreed Mine Closure Plan will also assist with mitigating adverse impacts resulting from land clearing. Where possible, existing disturbance such as the current road that accesses the project area have been utilised in order to minimise additional clearing of potential Greater Bilby habitat. Sheffield is working in close consultation with Traditional Owners to reach a Mining Agreement for the project. This agreement is anticipated to include support for land management activities by the Traditional Owners within the project area. Management measures specific to the Greater Bilby are documented in Section 13.4. A Preliminary Bilby Management Plan has also been prepared (Appendix 23).
Are any impacts of the proposed action on matters of National Environmental Significance likely to be significant impacts (important, notable or of consequence having regard to their context or intensity)?	The project area is located within land used for pastoral activities. It has been moderately impacted by pastoral activities (grazing, burning, introduced plant species, feral animals). Pastoral activities are ongoing and are outside the control of Sheffield. Based on consideration of the factors documented above, knowledge of the project area including results of site specific baseline ecological studies, significant impacts as defined under the *EPBC Act* are considered unlikely to result from implementation of the proposed action on the Greater Bilby. No other matters of national environmental significance are known to be within or adjacent to the proposed project area that could be directly or indirectly impacted by implementing the action.

Table 87: Significance Impact Criteria Assessment for Vulnerable Species

Significance Impact Criteria	Assessment
Lead to a long term decrease in the size of an important population of the species.	Baseline studies have identified the Greater Bilby is present within the Mine Site Development Envelope based on presence of scats, diggings, inactive and active borrows. DNA examination of scats identified at least 9 individuals present within the survey area. This is consistent with knowledge that the Greater Bilby is widely distributed across the Dampier Peninsula. Due to the highly mobile characteristics of the species, the number of individuals in any one area will likely experience significant change over time depending on regional as well as local conditions. The Bilby Population within the Mine Site Development Envelope is not considered to be an "Important Population" as defined by DoEE in that it is necessary for the long term survival and recovery of the species. It is acknowledged that animals present within the project area are however part of the Dampier Peninsula population which is important in terms of the animals survival in Western Australia. The project may impact individual animals and habitat as described in Section 13.2. Given the progressive nature of the project, the small total footprint in relation to the available habitat for the species, the current pastoral land use and the proposed management measures to minimise impacts, it is considered unlikely that a long term decrease in population will occur as a direct or indirect result of the implementation of the project.
Significantly reduce the area of occupancy of an important population.	The Mine Site Development Envelope is 5,875 ha in area. The direct area of impact over 40 + years is about 38.7% of this (2,272.8 ha) with an average of 200 ha cleared annually. Of the total area to be disturbed, 1,632.9 ha (71.8%) will be progressively rehabilitated and is expected to provide suitable habitat for use by the Greater Bilby as vegetation establishes over time. The remaining disturbance area (639.6 ha) will either be permanent disturbance associated with development of the Site Access Road or long term disturbance that will be rehabilitated after completion of the project. From this it can be seen that the project will not significantly reduce the area of occupancy on a local or regional scale of an important Greater Bilby population.
Fragment an existing population into two or more populations.	The Greater Bilby is known to be a highly mobile species. The Site Access Road upgrades an existing road on the pastoral station and will not add to any existing habitat fragmentation. The progressive nature of the proposed land clearing and associated rehabilitation within two years of clearing will minimise risks of habitat fragmentation. Additionally, sufficient Greater Bilby habitat remains around the periphery of the project to allow for movement and interactions within the current population base.
Adversely affect habitat critical to the survival of a species.	Baseline studies identified three habitat types within the Mine Site Development Envelope (5,875 ha). Of these Pindan Shrubland is the dominant habitat present (89.6%) and is considered preferable habitat for the Greater Bilby. Research currently being undertaken in the Western Kimberley has identified the Bilby is non-selective and uses a range of different habitat types. Sheffield in this impact assessment has taken a conservative approach and thus treated the whole Mine Site Development Envelope as potential habitat for the species. The Mine Site Development Envelope is 5,875 ha in area. This forms 14.5% of the total area surveyed during baseline studies (15,693.9 ha). The direct area of impact (i.e. area of land to be cleared) over 40 + years is about 38.7% of the Development Envelope (2,272.8 ha) with an average of 200 ha cleared annually. Of the total area to be disturbed, 1,632.9 ha (71.8%) will be progressively rehabilitated and is expected to provide suitable habitat for use by the Greater Bilby as vegetation establishes over time. The remaining disturbance area (639.6 ha) will either be permanent disturbance associated with development of the Site Access Road or long term disturbance that will be rehabilitated after completion of the project. From this it can be seen that while the project will cause removal of habitat in the short, medium and long term, this habitat is not significant on a local or regional scale and does not represent a habitat that is critical to the survival of the species.

Significance Impact Criteria	Assessment
Disrupt the breeding cycle of an important population.	The Bilby Population using the Mine Site Development Envelope area is part of a regionally important population as defined by DoEE, but it is not considered important on a local scale. The project will operate on a continuous basis i.e. 24 hrs per day, seven days per week. It is anticipated that individual animals will choose to preferentially use areas away from active operations due to the presence of people and noise and vibration emissions from operating equipment. Sheffield have committed to undertaking pre clearance surveys and implementing a Bilby relocation program if evidence of active Bilby use of an area planned to be cleared is detected. Project activities may disrupt breeding cycles on a local scale, but are unlikely to disrupt breeding activates on a regional scale that would adversely affect an important population.
Modify, destroy, remove, isolate or decrease the availability or quality of habitats to the extent that the species is likely to decline.	Whilst the project will remove habitat in the short term until vegetation has established sufficiently to support use of rehabilitated areas by the species, the small scale annual removal of habitat in a regional context is considered unlikely to modify, destroy, remove, isolate or decrease the availability or quality of habitats to the extent that the species is likely to decline.
Result in invasive species that are harmful to the Greater Bilby becoming established.	The project will result in the area not being used for cattle grazing during the life of the project (40 + years). This will have an impact on native vegetation and habitat quality for the Bilby. As described in Section 13.2.4, Sheffield have committed to a number of measures to minimise the risk of introduction of or increase in populations of pest animals.
Introduce disease that may cause the species to decline.	Introduction of disease that may affect Greater Bilbies is not a risk associated with implementation of the project. No animals will be introduced to the Mine Site Development Envelope that may act as vectors for disease spread.
Interfere substantially with the recovery of the species.	The area in which the project would be implemented is an active grazing lease. No actions are currently being taken to address recovery of the species within the pastoral lease area. Greater Bilbies currently co-exist with cattle within this landuse. Sheffield has committed to implementation of an Offsets package in recognition that land clearing will have impacts on habitat of the Greater Bilby and this species is of national conservation significance and has importance socially to a number of stakeholders including Traditional Owners. The aim of the key component of the proposed offsets package is to increase knowledge about the species within the Kimberley to allow for improved conservation efforts. If implemented effectively, this will assist with recovery of the species.

13.6 PREDICTED OUTCOME

The Mine Site Development Envelope is known to support Greater Bilbies. Consistent with other areas of the Dampier Peninsula, the Development Envelope will support Greater Bilbies in low densities with significant difference in population numbers at any point in time given the highly mobile nature of the species.

It is almost certain that clearing associated with the project will result in loss of some Greater Bilby habitat, as well as habitat fragmentation and displacement of individuals. Habitat loss given the nature of the mining process will be progressive and is not expected to be permanent apart from expansion of the existing Mt Jowlaenga Road to form the Site Access Road. Progressive rehabilitation of mined areas to the current land use (grazing of native pasture) will minimise long term habitat loss. Extensive habitat is available in the areas surrounding the Mine Site Development Envelope and thus it is considered feasible for individual Greater Bilbies to move away from the impact area and colonise this habitat during the duration of the project.

Clearing activities are also almost certain to result in the injury or death of some individual Greater Bilbies. Likewise, vehicle strike is almost certain to cause injury or mortality of some individuals. However, these injuries and mortalities are not expected to impact the ability of the Greater Bilby population to survive at the local or regional level.

Light and noise pollution are likely to disrupt the nocturnal activities of the Greater Bilby, but affected individuals are expected to move away from noise and light sources. Fauna injury or mortality due to increased predation, changes to the fire regime, or entrapment may occur, however are not considered likely to impact population viability or diversity.

Based on an assessment of the potential impacts on the Greater Bilby in accordance with the *EPBC Act* significant impacts guidelines (Table 87) it can be summarised that the project is not expected to:

- Lead to a long term decrease in the size of an important population of the species.
- Significantly reduce the area of occupancy of an important population.
- Fragment an existing population into two or more populations.
- Adversely affect habitat critical to the survival of a species.
- Disrupt the breeding cycle of an important population.
- Modify, destroy, remove, isolate or decrease the availability or quality of habitats to the extent that the species is likely to decline.
- Result in invasive species that are harmful to the Greater Bilby becoming established.
- Introduce disease that may cause the species to decline.
- Interfere substantially with the recovery of the species.

Sheffield is committed to managing the project such that the species would not be significantly affected. In recognition of the conservation status of the species and potential impacts on it, an offset package to mitigate impact is proposed. This is detailed in Section 14.

14. ENVIRONMENTAL IMPACT ASSESSMENT - INTEGRATING FACTOR - OFFSETS

The EPA's objective for offsets is "*to counterbalance any significant residual environmental impacts or uncertainty through the application of offsets*".

14.1 KEY STATUTORY REQUIREMENTS, ENVIRONMENTAL POLICY AND GUIDANCE

The application and assessment of environmental offsets for the project has been undertaken with consideration to the following:

- WA Environmental Offsets Guidelines (EPA 2014c).
- WA Environmental Offsets Policy (Government of WA 2011).
- Environmental Protection Bulletin No. 1 Environmental Offsets (EPA 2014b).
- Environment Protection and Biodiversity Conservation Act 1999 Environmental Offsets Policy (DSEWPC 2012a).
- How to Use the Offsets Assessment Guide (DoEE 2016a).
- Offset Calculation Excel spreadsheet with embedded formulae (DoEE 2016b).

14.2 ASSESSMENT OF OFFSET REQUIREMENTS

Under both the WA Environmental Offsets Guidelines and the Australian Government's Environmental Offsets Policy, environmental offsets are required where a project is likely to cause significant residual impacts. Residual impacts are unavoidable impacts that remain after avoidance, minimisation and rehabilitation have been pursued (EPA 2014b). Environmental offsets counterbalance the significant residual environmental impacts of a project (EPA 2014b).

The ESD identifies potential residual significant impacts of the project on flora, vegetation, and fauna habitat as a result of the following activities within the mining area:

- Land clearing for permanent infrastructure.
- Groundwater abstraction.

This PER has conducted the EIA for the project for Key, Other, and Integrating Environmental Factors within Sections 8 to 13. Sheffield has developed management and mitigation measures to minimise environmental impacts of the project. Design of the project has taken into account the mitigation hierarchy of:

- Avoid.
- Minimise.
- Rehabilitate.
- Offset.

Significant avoidance and minimisation measures have been incorporated into decision making and Mine Site design. Key actions that have resulted in avoidance or minimisation of impacts include the following:

- Mining rate - The proposed ore mining rate has been reduced from 18 Mtpa over 40 years, to an initial 7.5 Mtpa over the first five years, ramping up to 15 Mtpa with an extended production life of over 40 years.

This will reduce the area of clearing to be undertaken annually, as well as the area under rehabilitation at any one time. It will also reduce water requirements and the aquifer recovery time.

- Ore processing - The initial processing stage MUPs are located within the mining void so that no additional land clearing is required. These units are skid mounted and will be relocated as the mining void advances.
- Mining excavation - The initial mining location was selected based on minimising overburden removal requirements, to minimise the need for stockpiling outside the mining area. The mining footprint has been reduced from the original proposed footprint to maintain an adequate buffer for identified Aboriginal heritage sites.
- Excess water – The proposed reinjection of excess water is anticipated to assist the aquifer to recover more readily as opposed to surface discharge and/or surface storage and evaporation of excess water.
- Site access - Using the existing Mt Jowlaenga Rd, with modifications rather than construct a new access road will:
  - Avoid ephemeral watercourses and low lying areas likely to be subject to inundation during the wet season, thus minimising the need for engineered crossings.
  - Avoid heritage areas and any associated buffers.
  - Minimise additional land clearance and thus vegetation disturbance.

Rehabilitation will be undertaken progressively over the life of the mine, as overburden from new mining areas and waste from the processing plant will be used to backfill mined sections of pit. This would be followed by topsoil placement (resourced from recently cleared areas), deep ripping and direct seeding for final rehabilitation of the land surface. Detail on the proposed rehabilitation is included in Section 12 and the MCP in Appendix 4.

After application of the mitigation hierarchy, Sheffield considers that the project will have a significant residual impact on only one Key Environmental Factor – Terrestrial Fauna. Specifically the residual impacts are to the Greater Bilby, which is also a Matter of National Environmental Significance. The Greater Bilby is listed as Vulnerable under the *WC Act* and the *EPBC Act*.

The significant residual impacts identified in relation to the Greater Bilby are through direct clearing of habitat. Although Ecologia (2015a) state that the Greater Bilby prefer Pindan Shrubland habitat, a precautionary approach has been taken given that it is well documented that the Greater Bilby occurs across a wide range of habitats (Southgate 1990). A total proposed disturbance of 2,280 ha is required for the project. Of this, 1632.9 ha are temporary and will be progressively cleared over the 40+ year project timeframe. Of this amount, approximately 200 ha of mine pit will be open at any one time, with progressive backfilling and rehabilitation occurring as the excavation progresses. The remaining 639.6 ha are for permanent infrastructure required throughout the project life.

14.3 PROPOSED OFFSET STRATEGY

Consistent with the WA Environmental Offsets Guidelines, Sheffield intends for any environmental offsets to be relevant and proportionate to the significance of the environmental impact. Given that the Greater Bilby is a Matter of National Environmental Significance, the following principles from the *EPBC Act Environmental Offsets Policy* have also been considered in the development of an appropriate offsets package. Suitable offsets ae required to:

- Deliver an overall conservation outcome that improves or maintains the viability of the aspect of the environment that is protected by national environment law and affected by the proposed action.
- Be built around direct offsets, but may include other compensatory measures (direct offsets are offsets that maintain or increase a matter's viability, or reduce any threats of damage, destruction or extinction, providing a measurable conservation gain).
- Be in proportion to the level of statutory protection that applies to the protected matter.

- Be of a size and scale proportionate to the residual impacts on the protected matter.
- Effectively account for and manage the risks of the offset not succeeding.
- Be additional to what is already required, determined by law or planning regulations or agreed to under other schemes or programs.
- Be efficient, effective, timely, transparent, scientifically robust and reasonable.
- Have transparent governance arrangements including being able to be readily measured, monitored, audited and enforced.

14.3.1 Offset Calculation

The DoEE Offsets Guide was used to assess applicability of proposed offsets for the Greater Bilby.

The DoEE Offsets Guide and the draft EPA offsets calculators are difficult to use in an extensive land use zone, such as the Kimberley where the project is located due to the absence of freehold land. The majority of land in the surrounding project area that is likely to provide habitat for the Greater Bilby consists of long term (99 year) pastoral leases, Aboriginal reserves or Unallocated Crown Land. As a result, Sheffield has considered ways other than the purchase of land for an offsets package.

The EPA Offset Calculation Spreadsheet has also been used in the offset calculation process, and is provided in Table 88.

Table 88: EPA Offset Calculation Spreadsheet

	Mitigation			Significant Residual Impact	Offset Calculation Methodology				
	Avoid and Minimise	Rehabilitation Type	Likely Rehabilitation Success		Type	Risk	Likely Offset Success	Time Lag	Offset Quantification
Total proposed disturbance of no more than 2,280 ha of vegetation	2,499 ha of Bilby habitat within the Mine Site Development Envelope have been avoided. Management and mitigation measures in Section 13.4 include: • Clearing activities will be managed to ensure clearing is strictly limited to that necessary for operations. • Land clearing will be undertaking progressively over 40 + years with the amount of active disturbance minimised. • Disturbed areas will be rehabilitated progressively as they become available. • Topsoil and vegetation will be respread over rehabilitated areas to act as a seed source and mulch to protect the soil from erosion and provide habitat for fauna.	Mining areas progressively cleared and rehabilitated - 1,632.9 ha over 40+ years. Areas of mine infrastructure rehabilitated at end of mine life - 639.6 ha.	<u>Can the environmental values be rehabilitated?</u> Yes <u>Operator experience in undertaking rehabilitation?</u> Best practise rehabilitation techniques and methodology will be used. Site rehabilitation research and trials during the life of the project will focus on restoration of Bilby habitat. Results will be applied to ongoing rehabilitation. Proponent has no direct experience as this is their first project. Individual employees within the current team have significant mining experience including management of mine closure. <u>Credibility of rehabilitation proposed?</u> Success at Lennard Shelf (400 km east of Broome) shows that rehabilitation in the West Kimberley can be achieved. Restoration of landforms following mineral sands has been demonstrated in WA and in other areas of Australia. <u>What is the type of vegetation being rehabilitated?</u> Pindan Shrubland <u>Time lag?</u> Mining areas will be progressively rehabilitated throughout the 40+ year mine life.	<u>Extent</u> 639.6 ha of Greater Bilby habitat for life of mine infrastructure. <u>Quality</u> Condition of vegetation ranged from good to excellent (Mattiske 2016). Some low level disturbance, associated with cattle and some areas subject to fire. Quality varies across site. <u>Conservation Significance</u> Provides habitat for the Greater Bilby, which is Vulnerable under WC Act and EPBC Act. <u>Tenure</u> Pastoral lease <u>Time Scale</u> Life of mine (40+ years) plus time taken to complete rehabilitation.	Provide funds to establish a Kimberley Greater Bilby Trust; develop and implement a WA Bilby Record Database; provide logistical support for researchers; institute a feral animal control program within Mine site Development Envelope.	**Low** Sheffield is committed to providing funding for the offset initiatives. It is also expected that the offsets will be a condition of the Part IV environmental approval of the project.	N/A	N/A	<u>DoEE Calculator</u> The DoEE calculator indicates that an offset of 447.72 ha is required to adequately compensate for the long term/permanent loss of 639.6 ha habitat. Recent Ministerial Statements and offset packages for the Pilbara have resulted in offset values of between $1,500 to $3,000 per ha being applied. This equates to a value of between $671, 580 and $1,343,160 over the life of the project. **Establish the Kimberley Greater Bilby Trust - $750,000** The purpose of this Trust will be to administer funds for research into the Greater Bilby, support onground conservation actions, facilitate Traditional owner involvement in land management for benefit of the species and ensure public access to information on results of projects supported by the trust. Sheffield will commit a total of $750,000 over the life of the project with 60% of Sheffield funds to be allocated for completion of projects by the end of Year 20. **WA Bilby Record Database - $85,000** Work collaboratively with other interested stakeholders to develop and implement a WA Bilby Record Database and fund administration for 10 years. Estimated costs are $40,000 for establishment in the first year and $5,000 per year for 9 years for a total of $85,000. **Logistical support for researchers - $90,000** Provide logistical support for people undertaking relevant research projects (flights to site, accommodation, and field work assistance) for research projects. Estimated costs are $10,000 per person per project per year for a total of $90,000 based on three research projects for three years' duration each. **Feral animal control program - $225,000** Feral animal control within the Mine Site Development Envelope. It is recognised the project may result in increased predator populations. Sheffield will allocate $5,000 per year for 45 years for a total of $225,000. **Total package - $1,150,000** The offsets package proposed totals $1,150,000 over the life of the project which will generate significant positive outcomes for the Greater Bilby in the Kimberley.

Of the proposed clearing, 1,632.9 ha are classified as temporary for the mine excavation. Input to the offsets guide indicates rehabilitation in situ of this area is suitable as an offset for this clearing. The remaining proposed clearing of 639.6 ha is for permanent infrastructure for the life of project (40+ years). The DoEE calculator indicates that an offset of 447.72 ha is required to adequately compensate for the long term and permanent loss of habitat. Outputs from the DoEE Offsets Guide are provided in Appendix 27.

Recent Ministerial Statements and offset packages for the Pilbara have resulted in offset values of between $1,500 to $3,000 per ha being applied. Proposed offsets for the Thunderbird Mineral Sands Project have been calculated based on the residual impacts to the 639.6 ha for permanent infrastructure for the life of project. Using the DoEE calculated offset requirement of 447.72 ha and the rates of $1,500 to $3,000 per hectare, this equates to values of between $671, 580 and $1,343,160 over the life of the project. In line with other projects in the extensive land use zone, an offset will only be paid for actual clearing undertaken and this will be reconciled as part of the construction process.

14.3.2 Proposed Offset Package

Sheffield proposes an offsets package to mitigate the residual impacts of clearing 639.6 ha of Greater Bilby habitat through a combination of research funds and contribution to regional programs focused on gaining greater understanding of the Greater Bilby including improved collation of data relevant to the species.

Specifically, in order to offset significant residual impacts of the Greater Bilby, Sheffield proposes to:

- Establish the Kimberley Greater Bilby Trust. The purpose of this Trust will be to administer funds for research into the Greater Bilby. Sheffield will commit a total of $750,000 over the life of the project with 60% of Sheffield funds to be allocated for completion of projects by the end of Year 20.
- Work collaboratively with other interested stakeholders to develop and implement a WA Bilby Record Database and fund administration for 10 years. Estimated costs are $40,000 for establishment in the first year and $5,000 per year for 9 years for a total of $85,000.
- Provide logistical support for people undertaking relevant research projects (flights to site, accommodation, and field work assistance) for research projects. Estimated costs are $10,000 per person per project per year for a total of $90,000 based on three research projects for three year's duration each.
- Feral animal control within the Mine Site Development Envelope. It is recognised the project may result in increased predator populations. Sheffield will allocate $5,000 per year for 45 years for a total of $225,000.

The offsets package proposed totals $1,150,000 over the life of the project which will generate significant positive outcomes for the Greater Bilby in the Kimberley.

14.3.2.1 Kimberley Greater Bilby Trust

Sheffield will champion establishment of the Kimberley Greater Bilby Trust. The objectives of the Trust would be to:

- Facilitate priority research for the Greater Bilby in the Kimberley.
- Fund on-ground environmental and conservation management at the landscape level, with emphasis on net conservation benefits to the Greater Bilby.
- Facilitate indigenous involvement in land management and conservation activities relevant to the greater Bilby.
- Share outcomes of work supported by the Trust to assist with increasing effectiveness of conservation activities.

A Management Panel would be appointed to ensure the objectives of the Trust are achieved. Representation from regulatory authorities, NGO's, Traditional Owners and Sheffield as the founder are proposed.

Similar to the recently established Greater Victoria Desert Biodiversity Trust, Sheffield envisages the Kimberley Greater Bilby Trust would be open to contributions from a range of stakeholders to support this initiative.

Given the long life of the project and long term need for protection of the species, it is anticipated that research priorities will change over time, particularly as results of initial projects are published and understood. Establishment of the Kimberley Greater Bilby Trust would enable independent determination and prioritisation of research and conservation needs most effective for conservation of the species.

14.3.2.2 Establish and Implement WA Bilby Records Database

During stakeholder consultation, the issue of a lack of a centralised database for Greater Bilby records in Western Australia was raised. During baseline surveys it also became apparent that records obtained from DPaW data base searches are not comprehensive and do not include results from a range of work undertaken for the Greater Bilby. Other stakeholders with interests in Greater Bilby conservation have identified that conservation efforts would benefit from centralisation of records from scientific surveys (research institutions, regulators and private industry), surveys conducted by Traditional Owners and Aboriginal Ranger Programs.

Sheffield will commit funds to assist with establishment of such a records database and provide funding for ongoing maintenance.

14.4 PREDICTED OUTCOME

The proposed offset package is designed to counterbalance the loss of Greater Bilby habitat which has the potential to occur through permanent modification of habitat characteristics in the Mine Site Development Envelope. This will be achieved by reducing threats to the Greater Bilby, potentially improving habitat condition, and increasing numbers across the broader Dampier Peninsula.

Sheffield considers that the potential significant residual impacts to the Greater Bilby will be able to be counterbalanced by the proposed offsets package such that the environmental objective for offsets (Section 14) will be met.

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APPENDICES

APPENDIX 1: SECTION 43A APPLICATION AND APPROVAL

APPENDIX 2: CHECKLISTS

Checklist for Documents Submitted for EIA of Proposals that have the Potential to Significantly Impact on Sea and Land Factors

PART 1 – GENERAL QUALITY OF DOCUMENTS

Ensure that the following standard elements are present in all documentation (including appendices):

A clear and concise title that outlines basic information about the proposal and purpose of the document.	☑
Date and document revision number.	☑
Information identifying the document's author and publishing entity.	☑
All issues identified in a scoping guideline or scoping document have been addressed and covered in the report (note: there should also be a stand-alone document that explicitly considers each element of the scoping document and how/where it is addressed).	☑
Complete and correct tables of contents, maps, tables and figures.	☑
Suitably-sized scale maps placing the proposal into both a regional and local context.	☑
Figures, plates, maps, technical drawings or similar including scale bar, legend, informative caption, labels identifying important or relevant locations/features referred to in the document text.	☑
Proposed footprint and development envelope are shown on scale maps and associated spatial data is provided in an appropriate format and coordinate system/projection (GDA94/MGA Zone or GDA94). For EPA notes on spatial data please refer to Appendix 1 of Environmental Assessment Guideline No. 1 Defining the Key Characteristics of a Proposal.	☑
All survey site locations and derived data products (e.g. benthic habitat maps, vegetation maps) have been provided in map and appropriate electronic spatial data format.	☑
All survey data from biological surveys have been provided in electronic database form (Access/Excel) with coordinate system/projection specified (GDA94/MGA Zone or GDA94).	☐
A list of references that have been cross-checked to ensure that all references in the reference list are cited in the text (and vice versa).	☑
All information based on 'expert' opinion/judgement are explicitly attributed, by name and qualification, to a person/s or organisation.	☑
Where relevant, appendices are attached to the main EIA document that describe the details of technical work undertaken to underpin the content of the main document, and explicitly attributed by name to the author/s and (if applicable) their organisation.	☑
Description(s) of the proposal are internally consistent throughout all documentation and are couched to allow potential environmental impacts to be placed in local and regional contexts, including cumulative impacts of existing and approved developments. Please identify relevant sections of the report below:	☑

- *Section 3 – Project Description*

Descriptions of the local and regional environmental features most likely to be directly or indirectly affected by the proposal. Please identify relevant sections of the report in the box below: ☑

- *Section 4 – Existing Environment*

PART 2 – MARINE ENVIRONMENTAL ISSUES

For proposals where benthic communities and habitats is a relevant factor, and where it is likely to impact on tropical arid zone mangroves in the Pilbara, the EIA document describes how potential impacts have been addressed in the context of *Guidance Statement No.1: Guidance Statement for Protection of Tropical Arid Zone Mangroves Along the Pilbara Coastline (April 2001).* If applicable, please identify relevant sections of the report. N/A

For proposals likely to impact on benthic primary producer habitat, including tropical arid zone mangroves in the Pilbara, the EIA document describes how potential impacts have been addressed in the context of *Environmental Assessment Guideline No.3 Protection of Benthic Primary Producer Habitats in Western Australia's Marine Environment (December 2009),* including: ☑

- Details of the measures taken to address the Overarching Environmental Protection Principles; ☑
- Scale benthic habitat maps showing the current extent and distribution of benthic habitats and the areas of habitat predicted to be lost if the proposal proceeds; ☑
- Descriptions of technical work (e.g. benthic habitat surveys) carried out to underpin the benthic habitat map (e.g. a technical appendix); and ☑
- Clearly set out calculations of cumulative loss. N/A

If applicable, please identify relevant sections of the report in the box below:

- *Section 4.3.13 Benthic Primary Producer Habitat*
- *Section 11.1 Benthic Communities and Habitat*

For proposals likely to impact on benthic primary producer habitat in Port Hedland, the Local Assessment Unit for application of EAG 3 is consistent with *Environmental Protection Bulletin No. 14: Guidance for the assessment of benthic primary producer habitat loss in and around Port Hedland*. N/A

For proposals that involve marine dredging activities, potential impacts have been addressed in the context of the Environmental Assessment Guideline No. 7 for Marine Dredging Proposals (September 2011) to ensure that the predicted extent, severity and duration of impacts to benthic habitats are presented in a clear and consistent manner. N/A

For proposals that involve any type of waste discharge or disposal in State coastal waters potential impacts have been addressed in the context of: N/A

- *Environmental Assessment Guideline No.15 for Protecting the Quality of Western Australia's Marine Environment (EAG 15);* as well as
- *Environmental Quality Criteria Reference Document for Cockburn Sound (EPA, 2015)*, *Perth's Coastal Waters: Environmental Values and Objectives (EPA, 2000)*, or *Pilbara Coastal Water Quality Project Consultation Outcomes document (DoE, 2006)* for the relevant regions; and
- Relevant guidance provided in the *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZECC/ARMCANZ, 2000).

For proposals with potential to impact on an existing or proposed marine conservation reserve, potential impacts are couched in the context of the guidance provided in the relevant indicative or final Management Plan for the reserve on the advice of DEC or another designated management agency. If applicable, please identify relevant sections of the report. N/A

For proposals with light emissions likely to impact marine turtles, the potential impacts have been addressed in the context of *Environmental Assessment Guideline No. 5 Environmental Assessment Guideline for Protecting Marine Turtles from Light Impacts (November 2010)* to ensure appropriate avoidance and management approaches are in place. N/A

If numerical modelling has been carried out to inform the prediction of environmental impacts, the report(s) associated with this modelling, including the key assumptions, is (are) provided as a technical appendix. If applicable, please identify the relevant appendix in the box below. ☑

- Appendix 8 – H3 Hydrogeological Assessment
- Appendix 12 – Mine Site Development Envelope Air Quality Assessment
- Appendix 13 – Mine Site Development Envelope Noise Assessment
- Appendix 17 – Derby Port Development Envelope Air Quality Assessment
- Appendix 18 – Derby Port Development Envelope Noise Assessment
- Appendix 21 – Radiation Assessment

PART 3 – TERRESTRIAL BIODIVERSITY ISSUES

For proposals likely to impact on native flora and vegetation, the EIA document describes how potential direct and indirect impacts have been addressed in the context of *EPA Guidance Statement No. 51 - Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia (June 2004)* and *Technical Guide – Flora and Vegetation Surveys for Environmental Impact Assessment* EPA and DPaW (2015) including:

- Determining the level of flora and vegetation survey, including a survey area encompassing direct and indirect impacts, utilising suitable survey methodology and listing survey limitations; ☑
- Maps illustrating the survey area in both a local and regional context, location of quadrats, vegetation unit mapping, location of significant species or vegetation, vegetation condition and predicted extent of impact on the vegetation; ☑
- Maps and text describing the survey area/plot sites, location of significant species, vegetation mapping, vegetation condition assessment and predicted extent of impact on the vegetation; ☑
- A comprehensive list of flora species (using the nomenclature of the WA Herbarium) which are known or reasonably expected to occur in the area and a quantitative assessment of direct and indirect impacts to threatened, priority or other significant flora and/or threatened, priority or other significant vegetation (as defined in Technical Guide); ☑
- An evaluation of the impact of the proposal on flora and vegetation, including analysis of the local, regional and cumulative impacts of the project; and ☑
- Quadrat data provided as excel spreadsheet in raw form, in addition to hardcopy reports. ☑

If applicable, please identify relevant sections of the report below:

- Section 4.2.7 Flora and Vegetation (Existing Environment)
- Section 8.1 Flora and Vegetation (Environmental Impact Assessment)
- Appendix 9 – Flora and Fauna Studies

For proposals likely to impact on vertebrate fauna or fauna habitat, the EIA document describes how potential impacts have been addressed in the context of EPA Guidance Statement No. 56, *Terrestrial Fauna Surveys for Environmental Impact Assessment* (June 2004) and Technical Guide – *Terrestrial Vertebrate Fauna Surveys for Environmental Impact Assessment* EPA and DEC (2010), including:

- Determining the level of fauna survey consistent with that expected; ☑
- Describing the survey methodologies, including timing, duration and survey effort used to sample each of the fauna groups sampled, any survey limitations and the nomenclature used (WA Museum/Birdlife Australia); ☑
- Maps illustrating the survey area in both a regional and local context; fauna habitats within and outside the development envelope; description of predicted extent of impact on the habitat; location of survey sites and conservation significant fauna in relation to the proposal; and ☑
- A comprehensive list and assessment of vertebrate fauna known or reasonably expected to occur in the area, including Specially Protected, Priority and other significant fauna (as defined in Guidance Statement No. 56), and an evaluation of the impact of the proposal on the species and key habitat/s. ☑

If applicable, please identify relevant sections of the report in the box below:

- Section 4.2.8 Terrestrial Fauna and Habitats (Existing Environment)
- Section 4.3.10 Derby Port Development Envelope Terrestrial Fauna and Habitats (Existing Environment)
- Section 8.2 Terrestrial Fauna (Environmental Impact Assessment)
- Appendix 9 – Flora and Fauna Studies
- Appendix 9 – Peer Review of Fauna Surveys
- Appendix 11 – Fauna Which Have Potential to Occur at the Mine Site Development Envelope

For proposals with the potential to impact on short range endemic (SRE) invertebrate fauna or SRE habitat, the EIA document describes how potential impacts have been addressed in the context of EPA Guidance Statement No. 20, *Sampling of Short Range Invertebrate Fauna for Environmental Impact Assessment in Western Australia* (May 2009), including:

- Assessment for restricted habitat types that have potential to support SRE fauna, including advice from the WA Museum, DPaW and OEPA; ☑
- Maps illustrating the survey area in both a regional and local context, and identifying potential SRE habitats within and outside the development envelope and extent of predicted impact on the habitat; ☑
- A description of the survey methodologies, including timing and survey effort used to sample each of the fauna groups and any survey limitations; ☑
- The results and interpretation of any molecular analysis used; and ☑
- A survey report with assessment of SRE fauna found or reasonably expected to occur in the area, their conservation status, their known occurrence/habitats locally and their wider status if known, and an evaluation of the risk of the proposal to long-term survival of the species and community. ☑

If applicable, please identify relevant sections of the report in the box below:

- Section 4.2.8 Mine Site Development Envelope Terrestrial Fauna and Habitats (Existing Environment)
- Section 4.3.10 Derby Port Development Envelope Terrestrial Fauna and Habitats (Existing Environment)
- Section 8.2 Terrestrial Fauna (Environmental Impact Assessment)
- Appendix 9 – Flora and Fauna Studies
- Appendix 9 – Peer Review of Fauna Surveys
- Appendix 9 – Fauna Which Have Potential to Occur at the Mine Site Development Envelope

For proposals with the potential to impact on subterranean (stygofauna and troglofauna) fauna, the EIA document describes how potential impacts have been addressed in the context of EPA Environmental Assessment Guideline 12 Consideration of subterranean fauna in EIA in WA and EPA Guidance Statement No. 54 and 54a, *Sampling Methods and Survey Considerations for Subterranean Fauna in Western Australia* (Draft, August 2007), including:

- An assessment of the likely presence of habitat that could support subterranean fauna, including advice from the WA Museum and OEPA; ☑
- Maps identifying survey sites and illustrating the known or predicted extent of habitats in relation to the proposal; a description of the geology/habitat supporting subterranean fauna within and outside the development envelope; extent of predicted impacts on the subterranean fauna and habitat; ☑
- A description of the survey methodologies (see Guidance Statement No. 54a), including reference to site selection, sampling techniques, survey effort, specimen collection and molecular analysis used undertaken as part of the survey, and any survey limitations; and ☑
- A list of subterranean fauna recorded and their distribution or reasonably expected to occur in the area, including their conservation status, their known occurrence/habitats locally and their wider status if known, and an evaluation of the risk of the proposal to long-term survival of the species and community. ☑

If applicable, please identify relevant sections of the report below:

- Section 4.2.9 Subterranean Fauna (Existing Environment)
- Section 10.2 Subterranean Fauna (Environmental Impact Assessment)
- Appendix 9 – Flora and Fauna Studies
- Appendix 9 – Peer Review of Fauna Surveys
- Appendix 9 – Fauna Which Have Potential to Occur at the Mine Site Development Envelope

PART 4 – PROPONENT’S CERTIFICATION OF COMPLETENESS AND ACCURACY OF RESPONSES

Name
……………………………………………………………………………………………………

Position

……………………………………………………………………………………………………

Signature

……………………………………………………………………………………………………

Date ………..../…………/2017

Environmental Scoping Document Check List

ESD Item	Description/Task	PER Section
1	Characterise Derby Port marine environment quality via baseline contamination and acid sulfate soil assessment.	4.3.7
2	Undertake a radiological assessment of the products to be loaded and transported via Derby Port and King Sound.	
	A preliminary radiological assessment of mineral products from the Thunderbird Mineral Sands Project has been carried out by SGS (2014). It found the mineral products do not require transportation as radioactive substances.	10.5.2, Appendix 21.
	• Undertake detailed radiological assessment (in progress).	
3	Assess impacts of loading, barging and transhipment of mineral products, including impacts from radiation, on the marine environment quality. Radiation impacts will be assessed as part of an overall radiation assessment for the proposal.	9.1.2
4	Detail management and mitigation measures and further monitoring to achieve proposed outcomes and ensure residual impacts are not greater than anticipated.	9.1.3, Appendix 24
5	Undertake export activities in accordance with a Radiation Management Plan.	See letter to EPA dated 22/12/16.
6	Identify and characterise flora and vegetation within the Mining Area through Flora and Vegetation Survey in accordance with *EPA Guidance Statement 51*. The survey area should take into account vegetation that may be indirectly impacted and within the Mining Lease and Miscellaneous Licence boundaries to assist in determination of local and regional impacts. Flora and vegetation surveys have been completed:	
	• Level 1 Flora and Fauna Assessment (Ecologia 2012).	4.2.7
	• Level 2 Flora and Vegetation Survey (Ecologia 2014a).	
	Haul Road and Accommodation Camp Flora and Fauna Assessment (Ecologia 2015a).	
7	Conduct a detailed analysis of vegetation communities to establish local and regional conservation significance of each vegetation community:	
	Identify those communities which are likely to be groundwater dependent ecosystems (GDE). Provide details of the methodology used in the identification and mapping of vegetation community.	4.2.8.4
	Provide a detailed description with figures clearly showing vegetation communities including the potential Priority Ecological Community MaMvEtCpCc and the area to be cleared and indirectly impacted as defined in EPA Guidance Statement 51.	4.2.8.2, Figure 28
8	Conduct a technical peer review to ensure that surveys are relevant, representative of the development envelope, provide suitably current information on populations and locations of flora of conservation significance, and condition of vegetation units and have been carried out using methods consistent with EPA guidance.	
9	Should further or supplementary surveys be undertaken they will be consistent with the EPA/DPaW Technical Guide – Flora and Vegetation Surveys for Environmental Impact Assessment (2015).	4.2.7
10	Identify conservation significant species and communities present in the development envelope:	
	A Level 2 Flora and Vegetation Survey did not identify any declared rare flora (DRF) or EPBC Act listed species within 50 km of the study area. Three Priority 3 species were identified in the development envelope during the surveys. Of these, two were located in the proposed disturbance area.	4.2.8.3
	Conduct a targeted flora survey for conservation significant species (CS) in accordance with EPA Guidance Statement 51 and EPA and DPaW	4.2.7

ESD Item	Description/Task	PER Section
	Technical Guide – Flora and Vegetation Surveys for EIA.	
	Provide a detailed description with figures clearly showing Priority flora, range extension species and vegetation communities including the potential Priority Ecological Community (PEC) MaMvEtCpCc and the area to be cleared and indirectly impacted as defined in EPA Guidance Statement 51.	4.2.8.3
11	Predict the residual impacts from the proposal on flora and vegetation, both direct and indirect, after considering and applying avoidance and minimisation measures:	
	Quantify impacts on Priority flora species and range extension species, including the number of plants in the affected populations, the percentage of plants in the affected populations, the number of plants and populations to be impacted in a 'worst case scenario'.	8.1.2
	Provide information on the representation of Priority and range extension species on the remaining, unmined survey areas and other known occurrences/populations.	4.2.7
	Quantify the extent and duration of impacts on the different vegetation communities including MaMvEtCpCc which is similar to the Lolly Well Springs PEC and is associated with an ephemeral spring (potential GDE).	8.1.2
	Provide information on the representation of vegetation communities on the remaining, unmined survey areas. Analysis will include local and regional distribution of vegetation communities.	4.2.7
	Assess the impacts of altered surface hydrology and groundwater extraction on vegetation communities.	8.1.2
12	Identify management and mitigation measures for flora and vegetation to ensure residual impacts are not greater than predicted.	8.1.3
13	Summarise residual impacts, after considering avoidance and minimisation impacts are not greater than predicted.	8.1.4
14	Demonstrate and document in the PER how the EPA's objective for this factor can be met.	8.1.4
15	Complete the EPA Checklist for documents submitted for Environmental Impact Assessment on terrestrial biodiversity.	Appendix 2
16	Conduct terrestrial fauna surveys of direct and indirect impacted area and surrounds in accordance with *EPA Guidance Statement Number 56*. Conduct Targeted surveys of conservation significant fauna identified during fauna surveys that are significant. Fauna surveys and a Targeted Greater Bilby survey in accordance with *EPA Guidance Note 56* have been conducted as follows:	
	Level 1 Flora and Fauna Assessment (Ecologia 2012).	4.2.9
	Level 2 Terrestrial and Subterranean Fauna Assessment (Ecologia 2014a).	
	Haul Road and Accommodation Camp Flora and Fauna Assessment (Ecologia 2015a).	
	Targeted Greater Bilby Assessment (Draft) (Ecologia 2015b).	
17	Conduct a technical peer review of the Targeted Bilby Survey Report to ensure consistent with guidance and appropriate for the scale of impacts.	4.2.9, Appendix 9
18	Conduct a literature review and provide justification that completed fauna surveys are relevant, representative of the development envelope, provide suitably current information on populations and locations of fauna of conservation significance and have been carried out using methods consistent with EPA guidance.	4.2.9

ESD Item	Description/Task	PER Section
19	Assess direct and indirect impacts on fauna, conservation significant fauna and fauna habitats. Provide figures showing the likely extent of loss of habitat types and the extent of habitat areas expected to recover from both direct and indirect impacts. As part of the assessment, prepare a comprehensive list of all terrestrial fauna species likely to occur in habitats to be directly or indirectly impacted.	8.2.2
20	Assess the likelihood of the habitats to support short range endemic (SRE) invertebrate species. Provide figures clearly showing impacts to SREs.	8.2.2.3, 4.2.9.5
21	Identify management and mitigation measures to ensure residual impacts are not greater than predicted. The PER is to include a Greater Bilby Management Plan including environmental outcomes/objectives; other key regulatory requirements; management actions; monitoring (including methodology, frequency, location and rationale); trigger criteria; contingency actions; review, reporting and consultation.	8.2.3, Appendix 23
22	Demonstrate and document in the PER how the EPA's objective for this factor can be met.	8.2.4
23	Characterise the baseline hydrological and hydrogeological regimes and water quality, both in a local and regional context, including, but not limited to, water levels, water chemistry, stream flows, flood patterns, and water quantity and quality. This is to include a detailed description of the geological framework within the zone to be impacted by groundwater abstraction and any interdependence between surface and groundwater features/bodies.	4.2.5, 4.2.6
24	Identify borefield locations and design requirements to meet project needs (water supply and mine pit dewatering), expected abstraction over life of project, and sustainability of borefields.	3.5
25	Assess nature, extent and duration of potential impacts of groundwater abstraction with a focus on possible impacts on creeks, soaks/wetlands, groundwater dependent ecosystems and quality.	8.3.2, 8.4.2
26	Establish potential impacts and consequences that proposed mine infrastructure could have on existing surface drainage.	8.3.2.2
27	Identify any mine waste water discharges in the site water circuit (balance) and establish possible impacts these may have on the environment and mitigation measures.	3.5.2.3, 8.3.2, 8.4.2
28	The impact assessment will take climate change and cumulative effects into consideration.	8.3.2
29	Characterise hydrological properties for the port area including tides, flood levels and drainage.	4.3.8, 4.3.11.2
30	Describe proposed management, monitoring and mitigation methods to be implemented.	8.3.3
31	Undertake an investigation to characterise hydrogeological processes within the Mining Area and determine what effect the proposal will have on groundwater quality and quantity. This will include:	
	Hydrogeological conceptual model and numerical groundwater model of groundwater systems.	4.2.5.2, Appendix 8
	Site water balance.	3.5.1, 3.5.2
	Geochemical characterisation of aquifer sediments.	4.2.5, Appendix 8
	Potential for the aquifer to transport contaminants.	8.4.2
	Potential impacts on sensitive receptors.	8.4.2
32	Undertake an investigation to characterise hydrological processes within the Mining Area and determine what effect the proposal will have on surface water quality and quantity.	8.3.2, 8.4.2
33	Assess impacts of backfilling mine waste in mine pit void and TSF. Characterisation of mine waste backfill is addressed under 'Other Factor: Terrestrial Environmental Quality'.	8.4.2

ESD Item	Description/Task	PER Section
34	Detail management measures to ensure residual impacts on inland water quality are not greater than predicted.	8.4.3
35	Characterise noise impacts on sensitive receptors along the transport route and Derby Township via a noise assessment in accordance with *EPA Environmental Assessment Guideline 13*. Demonstrate that noise can be managed such that it complies with the *Environmental Protection (Noise) Regulations 1997* at sensitive receptor locations.	9.2.2.2, Appendix 18,
36	Provide noise predictions for noise-sensitive premises in relation to the proposed transport route, storage area and loading facilities including duration and severity of impacts.	9.2.2.2
37	Characterise air quality impacts on sensitive receptors along the transport route and at the Derby townsite.	9.2.2.1; Appendix 17
38	Demonstrate that the proposal has been designed as far as practicable to avoid and minimise impacts.	9.2.3
39	Identify and document in the PER management, monitoring, trigger and contingency actions, within environmental management plans, to ensure residual impacts (direct and indirect) are not greater than predicted.	9.2.3, Appendix 24
40	Demonstrate and document in the PER how the EPA's objective for this factor can be met.	9.2.4
41	Characterise the heritage and cultural values of the Mining Area and any other areas that may be indirectly impacted to identify sites of significance and their relevance within a wider regional context.	
	Conduct Aboriginal heritage surveys to identify Aboriginal sites of significance and identify concerns in regard to impacts from proposed mining operations.	4.2.13.1
42	Provide a detailed description of the heritage values of the Mining Area and provide a figure(s) of the heritage locations and proposed disturbance.	4.2.13
43	Assess the impacts of the proposal on heritage sites and/or cultural associations as a result of implementation of the proposal, including those arising from changes to the environment which may impact on ethnographic and archaeological heritage significance. This assessment will be conducted in accordance with *EPA Guidance Statement 41*.	8.5.2
44	Predict the residual impacts on heritage, for direct, indirect and cumulative impacts after considering avoidance and minimisation measures.	8.5.2
45	Outline the outcomes/objectives, management, monitoring, trigger and contingency actions to ensure impacts to heritage (direct and indirect) are not greater than predicted.	8.5.3
46	Describe the residual impacts for the proposal and analyse these impacts to identify and detail any that are significant.	8.5.4
47	If the proposal is likely to have any significant residual environmental impacts, identify environmental offsets, consistent with the requirements in the:	
	WA Environmental Offsets Guidelines, which includes the use of the WA Environmental Offsets Calculation Spreadsheet and EPA Environmental Protection Bulletin No.1: Environmental Offsets.	14.1, 14.2, 14.3.1
	DoE Environmental Offset Policy including the DoE Offsets calculation spreadsheet.	14.3.1
48	Provide an assessment on the physical and chemical characteristics of rehabilitation materials, including soil, mine and process wastes.	Appendix 4, Appendix 19, Appendix 20
49	Prepare a Mine Closure Plan consistent with DMP and EPA *Guidelines for Preparing Mine Closure Plans* (2015).	Appendix 4

ESD Item	Description/Task	PER Section
50	Describe the proposed rehabilitation methodology, including but not limited to:	
	Topsoil management.	Appendix 4
	Retention or reuse of cleared vegetation material.	Appendix 4
	Return of species and communities (where feasible) consistent with the pre-existing composition of the affected area.	Appendix 4
	Timeframes for rehabilitation, including sequencing of mining, backfilling and progressive rehabilitation.	Appendix 4
51	Characterise the benthic environment at Derby Port and mooring location through desktop assessment.	4.3.13
52	Assess the impact of minor dredging and installation works on the benthic communities and habitats.	11.1.2
53	Provide a summary of residual impacts of proposed works.	11.1.4
54	Document management and mitigation measures to ensure risk is not greater than predicted.	11.1.3
55	Assess the likely impacts to Humpback whales in their breeding and calving grounds off the Kimberley coast arising from shipping movements servicing the mine or exporting products from the mine.	11.2.2
56	Assess the consequential impacts of water abstraction for flow volumes in waterways, and indirect impacts on species such as the Norther River Shark and sawfish dependant on those waterways.	11.2.2.3
57	If appropriate, identify management and mitigations measures to ensure residual impacts are not greater than predicted. If warranted, the PER is to include a Humpback whale management plan including environmental outcomes/objectives; other key regulatory requirements; management actions; monitoring (including methodology, frequency, location and rationale); trigger criteria; contingency actions; review, reporting and consultation.	11.2.3
58	Demonstrate and document how the Commonwealth's objectives for this factor can be met.	11.2.4
59	Characterise affected landforms:	
	Describe the geology, soils and morphology of affected landforms.	4.2.4
	Determine the spatial extent of the landform and local assessment unit likely to be impacted.	4.2.4.2
	Compare and contrast the character and condition of the landform with others of the same type on a local and regional scale.	4.2.4
	Describe whether the landform is robust and less sensitive to damage or degradation from human activities, or whether it is easily disturbed or damaged.	4.2.4.1
	Assess the integrity of the landform, including the local assessment unit, and the degree to which the landform has been previously disturbed and fragmented.	4.2.4.2
60	Identify any ecological functions supported by the landform. Assess how the proposal will affect the role of the landform in maintaining these ecological functions.	4.2.4.2
61	Identify any significant scientific or evolutionary values associated with the landform.	4.2.4.2
62	Estimate the cumulative impacts on the landform and local assessment unit from reasonably foreseeable future development.	10.1.2

ESD Item	Description/Task	PER Section
63	Characterise the subterranean fauna environment in the Mining Area and surrounds. Undertake a subterranean fauna assessment in accordance with *Guidance Statement 54a*, of the direct and indirect impact areas (groundwater abstraction) including stygofauna and troglofauna.	
	A Level 2 subterranean fauna survey has been completed (Ecologia 2014b) and identified no conservation significant species of stygofauna or troglofauna.	4.2.10
	The survey found that the potential impact area is unlikely to contain a diverse or significant troglofauna community and as such no further sampling is required.	4.2.10
	It is unlikely that a significant or diverse stygofauna community exists within the study area.	4.2.10
64	Predict the severity, duration and extent of the impacts:	
	Assess the impacts of groundwater abstraction and water quality changes on subterranean fauna and their habitat as identified in Ecologia (2014b).	10.2.2
	Provide a summary of the findings of the impact assessment and Level 2 survey and supporting figures as required.	4.2.10, 10.2.2
65	Detail management measures to ensure residual impacts are not greater than predicted.	10.2.3
66	Characterise mine and process waste materials with potential to affect terrestrial environment quality:	
	Carry out materials characterisation of soils, mine and process waste materials. Materials characterisation will include geotechnical and geochemical characterisation of process residues. Characterisation will take into account all material types to be encountered throughout the mine life.	4.2.4.4, 4.2.7
	Carry out radiation assessment on waste to be placed within the mine pit. A preliminary radiation assessment has been carried out and determined the waste for mine pit backfilling, once blended with other waste, to be low level. A detailed assessment will be undertaken (in progress).	Appendix 21
	Carry out geotechnical assessment of the soil profile at key locations including the TSF to ensure stability and suitability of area for permanent waste disposal.	8.4.2.4
67	Identify aspects of the proposal which may impact terrestrial environment and predict severity and duration of impacts.	10.3.2
68	Identify management measures, outcomes/objectives to ensure residual impacts are not greater than predicted:	
	Impacts associated with materials management can be effectively managed under processes as defined in the Mining Act (1978) administered by DMP.	12
	Design, construction, management and closure of the TSF can be effectively managed under Mining Proposal and Mine Closure Plan in accordance with the Mining Act (1978).	12
69	Characterise baseline air quality in the Mining Area.	4.2.14
70	Describe expected impacts on air quality from the implementation of the proposal including direct and indirect diffuse and point emission sources.	10.4.2
71	Predict impacts from reduced air quality, particularly from point sources such as the secondary processing facility and power plant.	10.4.2
72	Estimate potential greenhouse gas emissions associated with construction and operation of the mine and associated infrastructure.	10.4.2.2
73	Document the proposed management, monitoring and mitigation methods.	10.4.3
74	Outline the objectives, management, monitoring, trigger and contingency actions within environmental management plans to ensure impacts are not greater than predicted.	10.4.3

ESD Item	Description/Task	PER Section
75	Characterise radiation and environment including sensitive receptors and predict the extent and severity of the impact. This will include consideration to exposure of long term mine and process waste disposal in the mine void and TSF, including the potential for tailings to become airborne and disperse as a result of dust from tailings. Identify measures, outcomes/objectives to ensure residual impacts are not greater than expected:	
	Undertake radiation assessment of ore, process streams, waste streams and final product and potential exposure pathways.	Appendix 21
	Radiation assessment of ore, process streams, waste streams and final product has been carried out by SGS (2014). Assessment found that the proposal will be considered a radiation practice requiring compliance with applicable regulations.	Updated by Radiation Professionals Appendix 21
	Further assessment is underway by SGS.	Updated by Radiation Professionals. Appendix 21
76	Characterise radiation aspects including the extent and severity of impacts on sensitive receptors. Identify measures, outcomes/objectives to ensure residual impacts are not greater than expected:	
	Undertake radiation assessment of mineral products to be transported and stored at Derby Port for ship loading.	11.4.2, Appendix 21
	Radiation assessment of product to be transported to Derby Port has been carried out by SGS (2014) and found the material to be below the threshold for transport as a radioactive substance.	Appendix 21
	Final products are below 10 Bq/g-1 but typically exceed 1 Bq/g-1 and consequently will be considered a radiation practice requiring compliance with applicable regulations.	Appendix 21
77	Radiation impacts can be effectively managed under the *Mines Safety and Inspection Act (1995)* and *Radiation Safety Act (1975)* jointly by DMP and Radiological Council of WA.	10.5

APPENDIX 3: SHEFFIELD ENVIRONMENTAL POLICY

APPENDIX 4: THUNDERBIRD MINERAL SANDS PROJECT MINE CLOSURE PLAN

APPENDIX 5: MINE SITE DEVELOPMENT ENVELOPE SURFACE HYDROLOGY STUDY

APPENDIX 6: MINE SITE DEVELOPMENT ENVELOPE SOIL AND LANDFORM ASSESSMENT

APPENDIX 7: LANDFORM ASSESSMENT METHODOLOGY

Regional 10 m contours for an area approximately 30 km surrounding the Mine Site Development Envelope were taken into consideration when defining the LAU. It was clear from a review of this regional elevation data that the key landforms in relation to the Mine Site Development Envelope were located in a north-west to south-east trending band parallel to the Mine Site Development Envelope. This area was therefore selected as the focus for defining the LAU.

The local assessment unit (LAU), and the landforms within this were derived through the use of contour line data (5 m intervals). Contours were obtained for the area surrounding the Mine Site Development Envelope and a digital elevation model (DEM) was derived from the contour data as a raster elevation surface using ArcMap 10.2. A slope surface was then derived from the DEM and all raster cells with a slope ≥5 degrees were extracted, converted to a vector polygon format, and used to define landforms in the LAU. Without specific guidance provided in the ESD, this approach was used as it is consistent with how the OEPA has defined landforms within a LAU for other projects where the Landform factor has been assessed.

The resulting regional landform shape file was simplified by zooming to the extent of the shape file, converting to a geo-referenced raster, and then converting back into a vector shape file. This approach was equivalent to buffering areas by 50 to 100m, smoothing the geometry and quickly merging smaller, more intricate groups of polygons into larger areas that better represented formations adequate for visualisation in the LAU.

This buffering was required because a slope raster was used as a base for the analytical process. When initially identifying areas where the slope was greater than five degrees, a discrete (or a directly definable) boundary was created. On the ground, the areas of greater than five degree slope actually form more of a continuous (or flowing/transitioning) boundary where values progressively change over distance as opposed to definitive cut-off line.

The process of simplifying/buffering was therefore carried out for three main purposes:

- As the real world boundary is continuous, the buffering process expands of the discrete boundary to encompass transitioning variations in slope across the terrain.
- As the analysis was based on defining discrete boundaries (greater than five degrees), polygons can be fragmented by holes or gaps. The smoothing and buffering removes these holes/gaps to create a more defined/single landform area.
- As the analysis used a raster as a base, the boundaries created follow a jagged pattern of the pixel geometry. The smoothing/buffering process removes jagged features and creates a more realistic and smoother boundary line.

APPENDIX 8: H3 HYDROGEOLOGICAL ASSESSMENT THUNDERBIRD MINERAL SANDS PROJECT

APPENDIX 9: FLORA AND FAUNA STUDIES OF THE THUNDERBIRD MINERAL SANDS PROJECT AREA

APPENDIX 10: PEER REVIEW OF FAUNA SURVEYS (WESTERN WILDLIFE 2016)

APPENDIX 11: FAUNA WHICH HAVE POTENTIAL TO OCCUR AT THE MINE SITE DEVELOPMENT ENVELOPE

APPENDIX 12: MINE SITE DEVELOPMENT ENVELOPE AIR QUALITY ASSESSMENT

APPENDIX 13: MINE SITE DEVELOPMENT ENVELOPE NOISE ASSESSMENT

APPENDIX 14: DERBY EXPORT FACILITY BASELINE CONTAMINATION AND ACID SULFATE SOIL ASSESSMENT

APPENDIX 15: NATUREMAP DATABASE SEARCH DERBY PORT AND TRANSHIPMENT ROUTE

APPENDIX 16: EPBC PROTECTED MATTERS DATABASE SEARCH DERBY PORT AND TRANSHIPMENT ROUTE

APPENDIX 17: DERBY PORT DEVELOPMENT ENVELOPE AIR QUALITY ASSESSMENT

APPENDIX 18: DERBY PORT DEVELOPMENT ENVELOPE NOISE ASSESSMENT

APPENDIX 19: THUNDERBIRD MINERAL SANDS MINE WASTE CHARACTERISATION

APPENDIX 20: THUNDERBIRD MINERAL SANDS PROJECT MINE RESIDUES CHARACTERISATION

APPENDIX 21: RADIATION STUDY

APPENDIX 22: VEGETATION MANAGEMENT PLAN

APPENDIX 23: BILBY MANAGEMENT PLAN

APPENDIX 24: GROUNDWATER MANAGEMENT PLAN

APPENDIX 25: PORT MANAGEMENT PLAN

APPENDIX 26: ABORIGINAL HERITAGE MANAGEMENT OPERATIONS FRAMEWORK

APPENDIX 27: DoEE OFFSETS CALCULATIONS