# Decision Report

## Application for Works Approval

**Division 3, Part V *Environmental Protection Act 1986***

| | |
|---|---|
| **Works Approval Number** | W6088/2017/1 |
| **Applicant** | Thunderbird Operations Pty Ltd |
| **ACN** | 611 351 743 |
| **File Number** | DER2017/001386 |
| **Premises** | Thunderbird Mineral Sands Project – Stage 1A<br>Great Northern Highway<br>WATERBANK WA 6725<br><br>Legal description –<br>Tenements M04/459 & L04/85 |
| **Date of Report** | 21 August 2018 |
| **Status of Report** | Final |

# Table of Contents

## List of Tables

## List of Figures

# 1. Definitions of terms and acronyms

In this Decision Report, the terms in Table 1 have the meanings defined.

**Table 1: Definitions**

| Term | Definition |
|---|---|
| ACN | Australian Company Number |
| AHD | Australian Height Datum |
| Applicant | refers to the applicant, as specified at the front of this Decision Report |
| Application | refers to the documents and information submitted by the Applicant, as described in section 3.1 and listed in Table 3 of this Decision Report |
| ASS | Acid Sulfate Soils |
| Bt | billion tonnes |
| Category/ Categories/ Cat. | Categories of Prescribed Premises as set out in Schedule 1 of the EP Regulations |
| Decision Report | refers to this document |
| Delegated Officer | an officer under section 20 of the EP Act |
| Department | means the department established under section 35 of the *Public Sector Management Act 1994* and designated as responsible for the administration of Part V, Division 3 of the EP Act |
| DBCA | Department of Biodiversity, Conservation and Attractions |
| DMIRS | Department of Mines, Industry Regulation and Safety |
| DWER | Department of Water and Environmental Regulation |
| EPA | Environmental Protection Authority |
| EP Act | *Environmental Protection Act 1986 (WA)* |
| EP Regulations | *Environmental Protection Regulations 1987 (WA)* |
| EPBC Act | *Environment Protection and Biodiversity Conservation Act 1999 (Cth)* |
| GL | gigalitre (one billion litres) |
| GL/a | gigalitres per annum |
| Implementation Agreement or Decision | has the same meaning given to that term under the EP Act |
| $m^3$ | cubic metres |
| mbgl | metres below ground level, with 'ground level' referring to the original (undisturbed) ground level at the particular location |
| Mining Act | *Mining Act 1978 (WA)* |
| Minister | the Minister responsible for the EP Act and associated regulations |
| MS | Ministerial Statement |
| MSP | Mineral Separation Plant |
| Mtpa | million tonnes per annum |
| NAF | Non-Acid Forming |
| PAF | Potentially Acid Forming |
| Prescribed Premises | has the same meaning given to that term under the EP Act |
| Premises | refers to the premises to which this Decision Report applies, as specified at |

| | |
|---|---|
| | the front of this Decision Report |
| Primary Activities | as defined in Schedule 2 of the Works Approval |
| Risk Event | as described in *Guidance Statement: Risk Assessment* |
| TSF | Tailings Storage Facility |
| WCP | Wet Concentration Plant |

# 2. Purpose and scope of assessment

Thunderbird Operations Pty Ltd (the Applicant) proposes to develop the Thunderbird Mineral Sands Mine. A concurrent application for works approval and licence was submitted by the Applicant under Division 3, Part V of the EP Act on 25 July 2017.

This Decision Report sets out the Delegated Officer's assessment of risks arising from emissions and discharges that will be generated by the Prescribed Activities conducted at the Premises.

# 3. Background

Thunderbird is a large scale heavy mineral sands mine proposed by the Applicant on the Dampier Peninsula within the west Kimberley region, approximately 75 km south-west of Derby and 90 km north-east of Broome, in the Shire of Broome.

The proposal was formally assessed in 2017 by the Environmental Protection Authority (EPA) at the level of Public Environmental Review (EPA Report 1606) and approved by the Minister for Environment on 10 August 2018 (Ministerial Statement 1080) (refer to section 5.1).

In July 2017, the EPA consented to the undertaking of 'minor or preliminary' works (preliminary works) on the Premises, in advance of the construction phase of the main Thunderbird project. The preliminary works include the development of two test pits, where 370,000 tonnes of material will be mined and processed over a 12 week period, and construction of the first 60 rooms of the mining accommodation camp (including supporting facilities). The preliminary works will cause the premises to become Prescribed Premises – Works Approval W6072/2017/1 was subsequently granted to authorise the initial mobilisation works in relation to the preliminary mining and processing activities.

## 3.1 Application details

The Applicant proposes to develop the mine in a staged process.

This Application relates to 'Stage 1A', which includes the commencement of mining, and construction and operation of the primary and secondary ore processing plants:

- Mining of mineral sands at a rate of 7.5 Million tonnes per annum (Mtpa) for years 1-4 and 15 Mtpa for years 5 to end of life (estimated 40+ years);
- Construction of a two-stage mineral sands processing facility, consisting of a wet concentrator plant (WCP) and a mineral separation plant (MSP);
- Expansion of the existing mining accommodation camp, including construction of a wastewater treatment plant and landfill facility; and
- Bulk storage of chemicals.

Table 2 describes the Prescribed Premises categories that the Application is subject, as defined in Schedule 1 of the EP Regulations.

**Table 2: Prescribed Premises Categories**

| Classification of Premises | Description | Premises throughput (as per Application) |
|---|---|---|
| Category 8 | Mineral sands mining or processing: premises on which mineral sands ore is mined, screened, separated or otherwise processed. | 7,500,000 tonnes per annual period |
| Category 54 | Sewage facility: premises –<br>(a) on which sewage is treated (excluding septic tanks); or<br>(b) from which treated sewage is discharged onto land or into waters. | 100 $m^3$ per day |
| Category 89 | 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. | 1,100 tonnes per annual period |

Table 3 lists the documents submitted for assessment relating to Stage 1A works.

**Table 3: Documents and information submitted for assessment of Stage 1A**

| Document/information description | Author | Date/version |
|---|---|---|
| Application form and supporting document | MBS Environmental | July 2017 |
| Appendix 1 – Letter seeking EPA consent for minor or preliminary works | MBS Environmental | 24 April 2017 |
| Appendix 2 – Works Approval Commitments | MBS Environmental | undated |
| Appendix 3 – Soil and Landform Assessment | MBS Environmental | October 2016 |
| Appendix 4 – Mine Waste Characterisation | MBS Environmental | October 2016 |
| Appendix 5 – Mine Residues Characterisation | MBS Environmental | October 2016 |
| Appendix 6 – Baseline Surface Hydrology Study | MBS Environmental | October 2016 |
| Appendix 7 – Environmental Noise Impact Assessment | Parsons Brinckerhoff | November 2016 |
| Appendix 8 – Multi-media Filtration Product Data Sheet | Makwater/ Clearmake | undated |
| Appendix 9 – Activated Sludge Bioreactor Product Data Sheet | Makwater/ Clearmake | undated |
| Appendix 10 – Air Quality Assessment | Atmospheric Solutions | 17 October 2016 |
| Appendix 11 – Hydrogeological Assessment | Rockwater | October 2016 |
| Appendix 12 – Radionuclide Mass Balance | Radiation Professionals | 8 December 2016 |
| Appendix 13 – Project Risk Assessment | MBS Environmental | undated |
| Further information on design details of equipment and infrastructure to be constructed (letter) | MBS Environmental | 31 August 2017 |
| Further information on design details for alternative wastewater treatment plant (letter) | MBS Environmental | 23 April 2018 |
| Further information on mine water balance and | MBS Environmental | 25 May 2018 |

| | | |
|---|---|---|
| updated construction timeframes (email) | | |
| Further design details on the proposed wastewater treatment plant (email) | MBS Environmental | 13 June 2018 |

The Applicant has broken Stage 1A into four construction phases, with separate commissioning reports to be submitted following the completion of each phase. Table 4 below describes the infrastructure to be constructed in each phase and the estimated construction and commissioning periods.

**Table 4: Construction and commissioning schedule for Stage 1A works**

| Phase | Infrastructure | Proposed construction commencement | Construction period | Commissioning period (weeks) |
|---|---|---|---|---|
| 1 | Construction water | Quarter 2, 2018 | 5 weeks | 1 |
| | Mine access roads | Quarter 3, 2018 | 12 weeks | 2 |
| 2 | Accommodation camp | Quarter 2, 2018 | 7 months | 4 |
| | Wastewater treatment plant | Quarter 2, 2018 (Stage 2) | 4 weeks | 6 months following completion of Stage 3 |
| | | Quarter 3, 2018 (Stage 2) | 4 weeks | |
| | Landfill | Quarter 3, 2018 | 2 weeks | 1 |
| | Pre-production mining | Quarter 1, 2020 | 8 weeks | N/a |
| 3 | Process plant (WCP1 & MSP1) | Quarter 3, 2018 | 110 weeks | 16 |
| 4 | Process plant (WCP2 & MSP2) | Quarter 1, 2024 | | |

**Key Findings:**

1. The Application for Stage 1A does not include the disposal of mine wastes (tailings), therefore any approval for Stage 1A would not include the disposal of mine wastes, or any activity that would generate mine waste (i.e. primary and secondary processing of mined ore).
2. A separate application will be submitted for “Stage 1B”, which will include construction and operation of an out-of-pit tailings storage facility, in-pit tailings disposal, and construction and operation of a product load-out facility. As such, commissioning of the constructed mining infrastructure will only be permitted under the Stage 1B approval.
3. A separate application will also be submitted in the future in relation to aquifer re-injection of mine water, with hydrogeological modelling indicating this will not be required until at least year 32 of mine operation.
4. The mobile package wastewater treatment plant that was installed during the preliminary works period will be replaced by a larger, permanent wastewater treatment plant and forms part of the risk assessment for this Application.
5. The borrow pit that was excavated for road construction purposes and utilised as the mine landfill during the preliminary works period will be expanded and forms part of the risk assessment for this Application.

# 4. Overview of the Thunderbird Mineral Sands Mine

The Application seeks to develop an open pit mine, processing plants and supporting infrastructure for the mining and processing of heavy mineral sands over a mine life of around 40 years.

The Thunderbird deposit has a total mineral resource of approximately 3.2 Billion tonnes (Bt) @ 6.9% heavy mineral (measured, indicated and inferred), comprising 18.5 Million tonnes (Mt) zircon, 61.8 Mt ilmenite and 5.9 Mt leucoxene. Initially, the mining rate will be 7.5 Million tonnes per annum (Mtpa), doubling to 15 Mtpa after the first 4 years.

The proposed mining technique involves strip mining and backfill method. Ore will be initially screened and processed at the active mine face, with process water used to create a slurry which will be supplied from local groundwater resources adjacent to the mine pit and stored in a nearby pond. Mine waste (tailings) will be initially stored within a designated tailings storage facility (TSF) until the initial mine void has been opened up for backfilling.

For the first 15 years all mining will be conducted above the water table (at approximately 35 metres below ground level, mbgl) at which point dewatering will be required to access the remaining orebody.

A summary of the Application is provided in Table 5.

**Table 5: Summary of the Application**

| Element | Description |
|---|---|
| Premises name | Thunderbird Mineral Sands Mine |
| Mine status | Undeveloped 'greenfield' project |
| Commodity mined | Mineral sands |
| Life of mine | 42 years |
| Land tenure | M04/459 and L04/85 are held exclusively by the Applicant<br>The land comprises pastoral lease held by a third party |
| Ore quantity | 680.7 Mt |
| Overburden removed | 523.3 Mt |
| Total material disturbed | 1.21 Bt (includes topsoil 6.6 Mt) |
| HMC recovered | 61.2 Mt (32.6 Mt of product) |
| Mine waste (tailings) | 648 Mt |
| Pit depth | Up to 100 m below ground level (towards the end of mine life) |
| Area of disturbance | 16.22 $km^2$ |
| Clearing | 1,961.1 hectares (within a 5,648 ha disturbance envelope) |
| Dewatering | Abstraction (up to 33 GL/a) once mining commences below the water table (around Year 15)<br>Reinjection (up to 22 GL/a) to the Broome Sandstone Aquifer (around Year 32) |
| Ore processing | On-site primary and secondary processing of ore to produce zircon, ilmenite and leucoxene products |

The Premises is located within Mining Lease M04/459, which is 4,525 ha in total area. This lease falls within the Mt Jowlaenga Pastoral Lease, which is also an active a cattle station managed by a third party. Much of the land surrounding the Premises comprises active pastoral leases, with several indigenous communities nearby.

The Thunderbird orebody covers an area approximately 7 km long and up to 5 km wide in

places. The total disturbance area (i.e. the orebody and disturbance areas required for access and mine infrastructure) is 1,934.1 ha (Figure 1). Table 6 provides a summary of the disturbance area by type over the mining lease, and a miscellaneous lease (L04/85) associated with the mining accommodation camp.

Construction of the two WCPs and MSPs will also commence Q3 2018. The construction period is estimated at 110 weeks (Q3 2020), followed by a 16-week commissioning period.

**Table 6: Area of disturbance by mining lease**

| Disturbance type | Mine activity reference | M04/459 (ha) | L04/85 (ha) |
|---|---|---|---|
| Mine voids and processing plant | Mining void | 1,630.0 | - |
| | Processing plant (WCP1, WCP2, MSP1, MSP2, process water storage, power station, plant laydown, office, concrete batching plant) | 60.0 | - |
| | Infrastructure corridor plant | 42.0 | - |
| Stockpiles | Topsoil stockpile | 18.0 | - |
| Other infrastructure | Tailings storage facility (initial) | 134.0 | - |
| | Borefield | 15.0 | - |
| | Landfill | 8.1 | - |
| Camp | Accommodation camp | - | 13.5 |
| | Access road | - | 6.5 |
| | WWTP and spray field | - | 25.0 |
| **Total tenement area** | | **1,889.1** | **45.0** |
| **Total mine activity area** | | **1,934.1** | |

## 4.1 Construction and site development

The construction and site development phase of Stage 1A will take over 2 years, with mining operations expected to commence Q1 2020. The initial site development works include construction water facilities, mine access roads, the worker's accommodation camp, wastewater treatment plant and landfill. Pre-production mining and stockpiling will be conducted over an 8 week period, commencing Q1 2020.

### 4.1.1 Mining infrastructure

Pre-production mining

An initial starter pit, measuring 80 m x 100 m, will be excavated using a truck and excavator fleet, in order to situate the in-pit feed infrastructure prior in preparation for start-up, commissioning and mining:

- Topsoil and subsoil – will be stripped from the starter pit and stored off the mine path;
- Overburden – the starter pit area contains no overburden;
- Mined ore – will be processed as it is mined (no stockpiling).

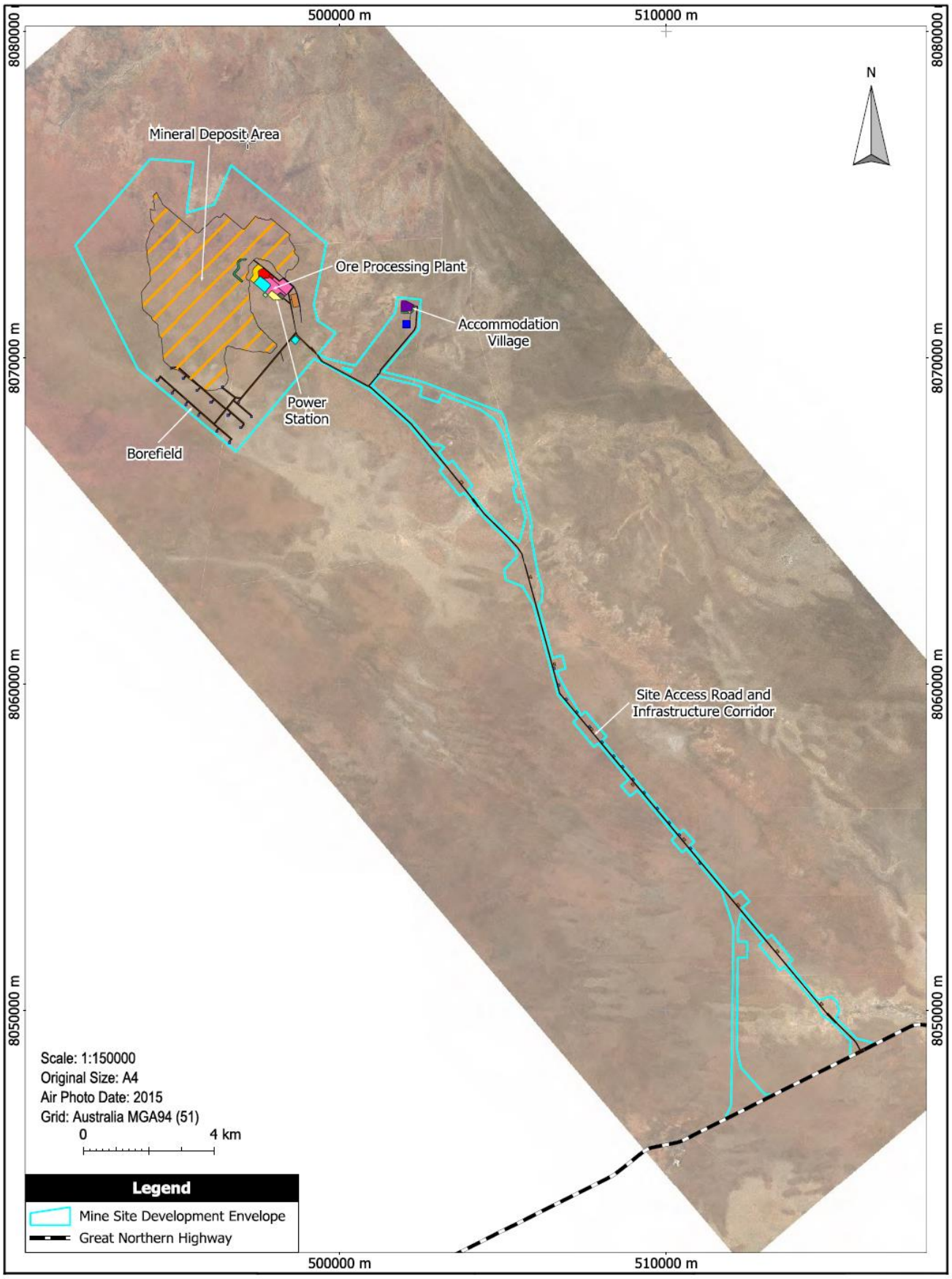


***Figure 1: Mine site development envelope – infrastructure layout***

Commissioning of mine infrastructure

The commissioning process will be carried out over a 4 month period, and includes:

- Pre-commissioning – static checks on unpowered equipment to confirm the infrastructure has been built according to manufacturer specifications;
- Dry commissioning – test operation of 'empty' equipment and facilities without the addition of fuel, reagents, ore, water or air; and
- Wet commissioning – test operation of equipment and facilities with fuel, reagents, ore, water and air. Wet commissioning of each component will not begin until pre-commissioning and dry commissioning tests have been passed. During wet commissioning, material feeds to the processing plant and will be gradually increased until they reach the steady state design volumes.

Approximately 2.7 Mt of ore will be processed as part of wet commissioning, with the heavy mineral concentrate (HMC) stored in a stockpile adjacent to the WCP. Management of the tailings streams produced during commissioning is discussed in section 4.2.5 below.

### 4.1.2 Sewage treatment plant

Design specifications

A new packaged sewage treatment plant will be installed to service the worker's accommodation camp and to treat the influent to an acceptable standard for irrigating a designated spray field containing native vegetation. The plant infrastructure will comprise two side-by-side containerised systems, designed to service around 300 workers over the initial 2 year construction period (and subsequent shutdown and maintenance periods when worker numbers increase), and 180 permanent workers over the remaining life-of-mine.

Each system will be housed in a 40 ft. sea container, positioned on an above ground leveled earthen pad, with external balance, sludge and irrigation tanks. All internal tanks will consist of reinforced polyethylene sections; external tanks will be constructed of molded polyethylene.

Commissioning of sewage treatment plant

The commissioning (testing) process will comprise the following phases:

- Pre-commissioning – static checks on unpowered equipment to confirm the packaged plant has been installed according to manufacturer specifications. This process will not involve the use of any chemicals, water or wastewater;
- Wet commissioning – test operation of the packaged plant and all associated tanks and pipework with water. Wet commissioning of each component will not begin until pre-commissioning tests have been completed; and
- Commissioning – test operation of equipment and facilities with chemicals and wastewater. This phase will not begin until wet commissioning tests have been completed, and will comprise the following:
  - Material feeds to the plant will be gradually increased until they reach the steady state design volumes;
  - Treated effluent will be collected and recycled to the plant as required;

**Treated effluent water quality will be established according to a sampling and validation program. Treated effluent will not be disposed of unless the measured chlorine residual complies with the requirements given in**

  - Table 7; and
  - Treated effluent will then be disposed to the irrigation spray field.

Commissioning will be complete when treated effluent with a residual chlorine concentration in the range 0.2 – 2.0 mg/L has been disposed to the irrigation spray field over 7 days.

**Table 7: Treated effluent specifications**

| Parameter | Unit | Value |
|---|---|---|
| Biochemical Oxygen Demand (BOD) | mg/L | <20.0 |
| Total suspended solids | | <30.0 |
| Total nitrogen | | <30.0 |
| Total phosphorus | | <8.0 |
| Chlorine residual | | 0.2 – 2.0 |
| pH | No unit | 6.5 – 8.5 |
| *E. coli* | cfu/100mL | <1,000 |

### 4.1.3 Landfill

A putrescible landfill will be constructed for the disposal of municipal type waste generated from the 300 construction workers over a 2 year period and 180 permanent workers over the life-of-mine. The landfill will be located in proximity to the processing plant and will incorporate an unlined trench design, with trenches progressively excavated when required.

## 4.2 Operational aspects – mining

The mining and processing operations will incorporate conventional dry mining, followed by wet concentrating, utilising industry standard mineral sands separation technology to produce HMC or intermediate products rich in ilmenite, leucoxene, rutile and zircon.

The HMC (averaging 1,457,758 tonnes per annum (tpa)) will then undergo secondary processing to produce five final products: LTR ilmenite, primary zircon, zircon concentrate, titano-magnetite, and HiTi88 leucoxene.

### 4.2.1 Timing and staging

The life of mine is estimated at 42 years, and will be operated in two stages:

- Stage 1: single mining unit plant and processing facility targeting mining and processing of approximately 7.5 Mtpa of ore from Years 1 – 4; and
- Stage 2: two mining unit plants and additional processing capacity targeting mining and processing of approximately 15 Mtpa of ore for the remainder of mine life.

Stage 2 will commence approximately 4 years after Stage 1, with full production (15 Mtpa) expected to commence around Year 5. Total material movements will vary over the mine life to enable a consistent ore stream matching the above processing rates.

### 4.2.2 Mining operations

**Mining is anticipated to commence Q1 2020, following the commissioning period. commence in the northern section of the orebody and progressively expand outwards south-westerly direction. The current indicative mine schedule is illustrated in**

*Figure 2*, indicating the approximate timing for mining of ore.

The general sequence of mining operations is outlined below:

- vegetation clearing and topsoil stripping;
- overburden removal and stockpiling;
- extraction of mineral sands ore using conventional dry mining equipment (e.g. trucks, excavators, dozers and loaders);

- screened ore pumped as a slurry to the WCP;
- backfilling of sand residues (i.e. clay fines, sand tailings, coarse rejects (oversize), and tailings from secondary processing) following mineral processing to the active mining area (behind the advancing ore extraction area); and
- progressive rehabilitation behind the advancing mining operation.

### 4.2.3 Ore processing

The mining operation will be progressive, with mined areas undergoing progressive backfilling and rehabilitation. Up to 200 ha of pit area will be open at any one time.

During Stage 1 mining (7.5 Mtpa), four large dozers will deliver the ore to a single 810 tonnes per hour (tpa) skid mounted dozer trap mining unit plant (MUP) located on the mine floor.

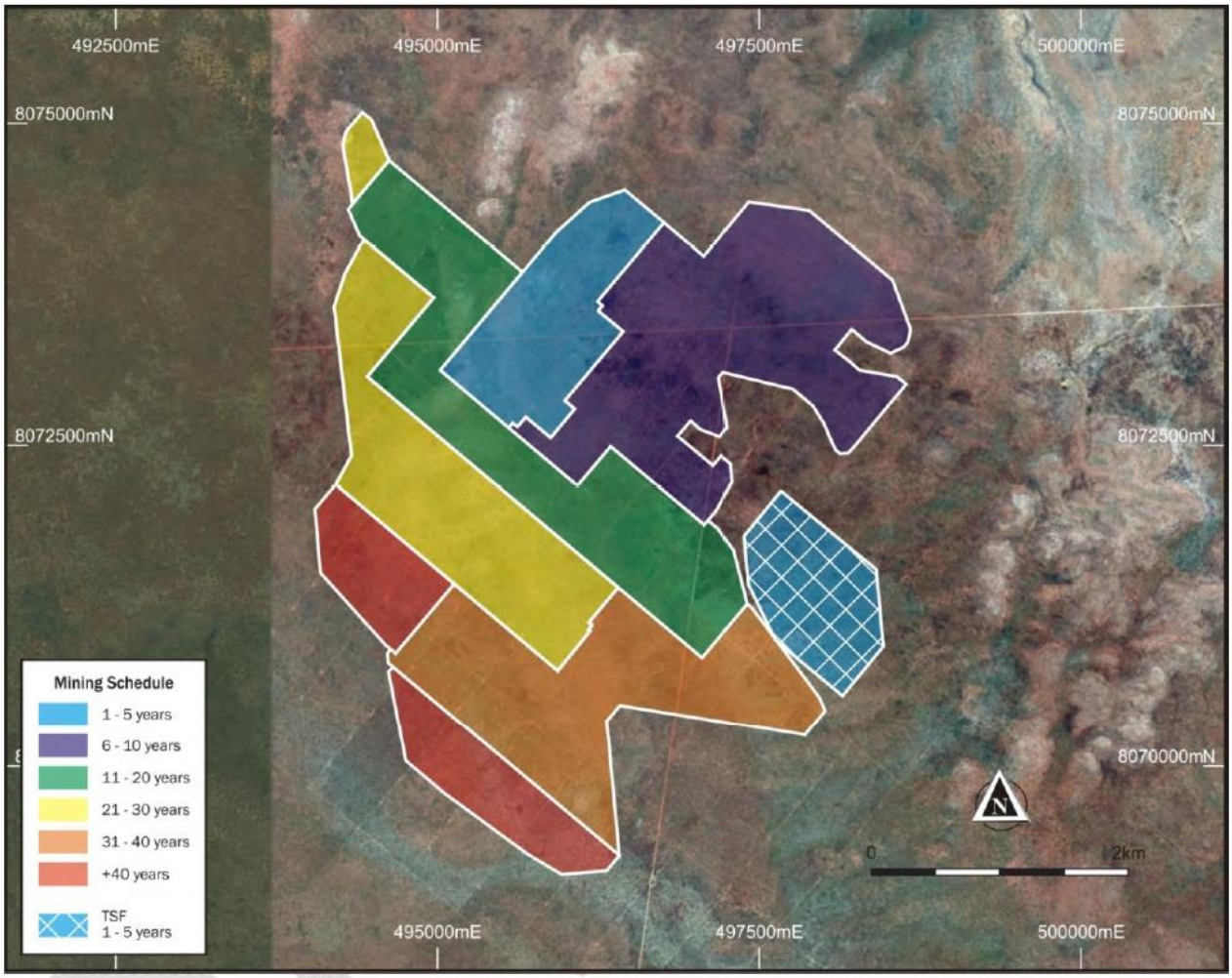


***Figure 2: Proposed mining schedule***

During Stage 2 mining (15 Mtpa), an additional MUP and supporting equipment/plant will be deployed. Ore mining will be supported by a fleet of loaders and 100 tonne trucks.

The MUPs will screen coarse oversize and trash material, with the remaining material reporting as ‘undersize’ and fed to a scrubber trommel, for transfer in a slurry form to a primary processing plant (i.e. WCP) in close proximity to the active mining face.

#### *4.2.3.1 Primary processing – Wet Concentrator Plant*

The WCP will likely be moved a number of times as the active mining face moves over time and to minimise slurry pumping distances.

The slurry line from the MUPs will feed a feed preparation plant, consisting of a trommel screen, which will screen out oversize greater than 2 mm. The undersize will be pumped to a de-sliming circuit consisting of cyclones. Overflow from the de-sliming circuit will report to a thickener to reject slimes and recover water for recycling within the process.

The de-sliming circuit underflow will be fed to a series of gravity spirals where the heavy minerals with high (> 3.5) specific gravities will flow to the inside of the spirals and separate from the principal waste mineral quartz, which has a low (< 3) specific gravity and will travel towards the outside of the spirals. This process will recover the majority of the heavy mineral as HMC, which will typically comprise 90 – 95% valuable heavy minerals (principally ilmenite, leucoxene, zircon and lesser amounts of monazite) on a dry weight basis.

**Key emissions:**

1. MUP oversize (>5 mm) and feed preparation plant coarse rejects (2 – 5 mm) will be stockpiled for use as roadbase/construction or returned to the mine void.
2. **Tailings** – initial gravity separation slimes/clay fraction from the thickener and waste non-heavy mineral sand tailings from the spirals circuit will report to a co-disposal plant, where both streams will be combined for disposal to the initial TSF, and later, to the mining voids.

#### *4.2.3.2 Secondary processing – Mineral Separation Plant*

Secondary processing in the MSP will comprise the following unit processes:

- Concentrate Upgrade Plant;
- Hot Acid Leaching;
- Primary Dry Mill;
- Zircon processing; and
- Ilmenite processing including low temperature roasting.

A summarised process sheet is provided in *Figure 3* below. Reagents used in ore processing will include acid and caustic soda and lime in the hot acid leach circuit, in addition to flocculants to assist in settling fine particles in the tailings thickeners and co-disposal streams.

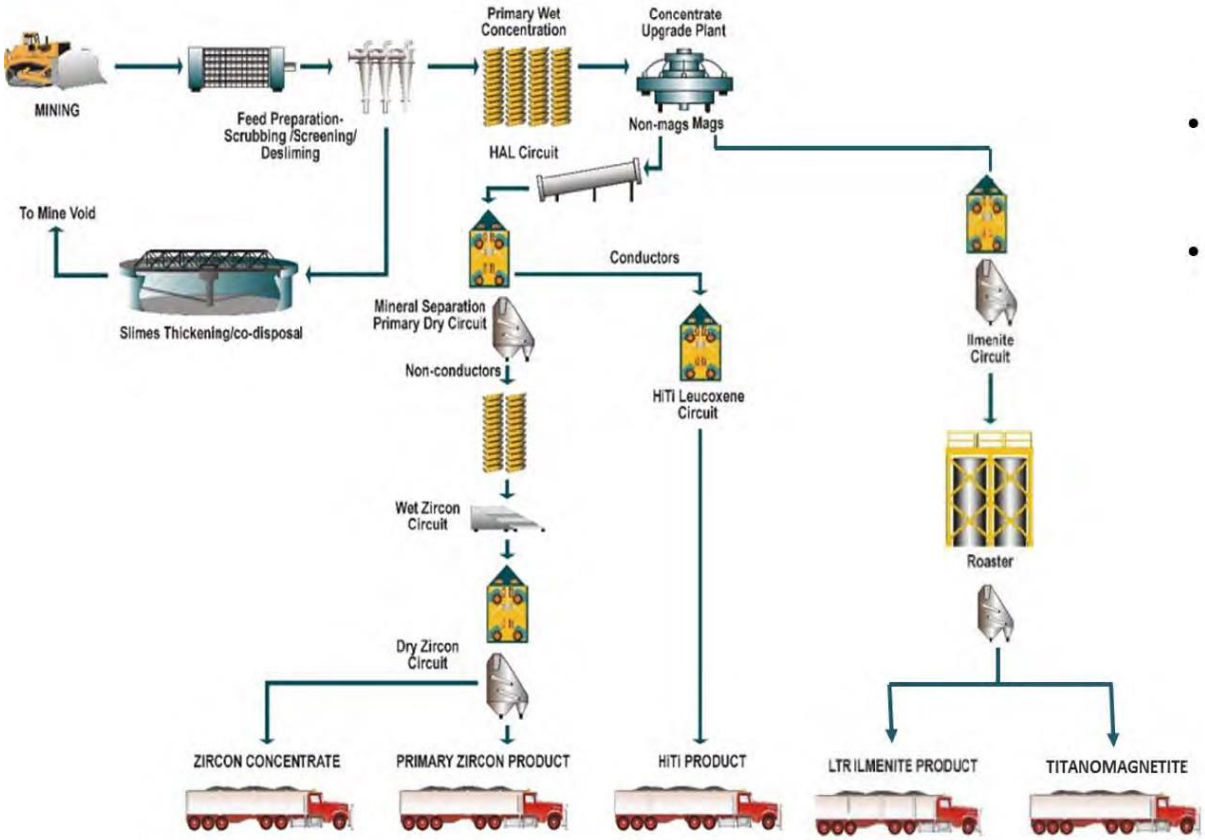


***Figure 3: Ore processing process flow sheet***

Concentrate Upgrade Plant

HMC from the WCP will feed the concentrate upgrade plant (CUP), which is designed to separate the magnetic minerals (ilmenite) from the non-magnetic minerals (zircon) using wet high intensity magnetic separators (WHIMS), and then further upgrade the non-magnetic fraction using spiral separators.

The non-magnetics stream will feed the hot acid leach circuit (HAL) and the magnetic stream will feed the ilmenite dry plant (IDP).

**Key emissions:**

1. HMC from the WCP will be dewatered via cyclones, stockpiled and allowed to drain. Overflow from each HMC dewatering cyclone and runoff from the HMC stockpiles will report to a sand trap before reporting to the CUP clarifier.
2. **Tailings** – CUP final tails and underflow from the CUP clarifier will be pumped to the initial TSF, and later, to the mining voids, for disposal.
3. Dewatering cyclone overflows will be recycled either via the CUP clarifier or via a solids trap.

Hot Acid Leach

The HAL circuit is designed to remove surface iron and calcium oxide coatings from the non-magnetics using a leach reactor, where strong acid is contacted at high temperature with the mineral in a rotary kiln. The leached concentrate will then be washed and any residual acid neutralised with caustic soda, prior to being passed through a series of gravity spirals and a wet shaking table. The final leached non-magnetic concentrate will feed the Primary Dry Mill.

**Key emissions:**

1. **Emission to air** – before entering the reactor, the non-magnetic feed will be preheated to 160°C through a fluidized bed dryer. Waste gases from the dryer will pass through a baghouse (fabric filter) to remove particulate matter, prior to discharge to the atmosphere via a 30 m stack.
2. **Emission to air** – acidic fumes from the reactor will be drawn off and scrubbed in a fume scrubber (wet spray), prior to discharge to the atmosphere via a 30 m stack. Acidic scrubbing water will be regularly replaced, with the purged water sent to an acid neutralisation plant for neutralising with a 'milk of lime'.
3. Overflow from both the reactor and attritioner will be sent to an acid neutralisation plant for neutralising.
4. **Tailings** – final tailings from the shaking table will report to a high-value tailings stockpile located in the CUP, via a dewatering cyclone.

Primary Dry Mill (Primary Electrostatic Separation)

The leached non-magnetic concentrate will be separated into minerals with conductive properties (e.g. ilmenite, leucoxene and rutile) from non-conductive minerals (e.g. silica, zircon, monazite and kyanite) using seven stages of high-tension roll separators (HTRs) (Primary HTR circuit).

The non-conductive minerals will pass over two further stages of rare earth rolls (as part of the Primary HTR circuit) to produce a non-magnetic zircon concentrate, which will be further processed through a wet circuit (see below).

The conductive minerals will be further separated through a further three stages of HTRs (Hi-Ti88 production circuit) to produce a '***HiTi88 leucoxene***' product.

**Key emissions:**

1. **Emission to air** – the leached non-magnetic concentrate will be dried through a fluidized bed dryer, prior to separation into conductors/non-conductors. Waste gases from the dryer will pass through a baghouse (fabric filter) to remove particulate matter, prior to discharge to the atmosphere via a 30 m stack.
2. **MSP rejects** – magnetics from the Primary HTR circuit and non-conductors from the Hi-Ti88 production circuit report to reject bins.

Wet zircon processing (WZP)

Impurities, such as iron oxide and silica, will be removed from the non-magnetic zircon concentrate by means of gravity concentrators. The concentrate will be pulped with water and then concentrated through three spiral stages and two wet shaking tables, with the resulting concentrates being combined to serve as feed for the Dry Zircon Processing Plant (DZP).

**Key emissions:**

1. **Tailings** – WZP tailings will report to a high-value tailings stockpile located in the CUP, via a dewatering cyclone.
2. The DZP feed is dewatered via a cyclone and a belt filter, prior to being fed to the DZP. Cyclone overflows from WZP tailings and filtrate from the DZP belt filter will be recycled as process water.

Dry zircon processing

The final stage of zircon refining will involve removing further impurities such as rutile and leucoxene from the wet zircon concentrate with five stages of HTRs, to produce a '***primary zircon***' and a '***zircon concentrate***'.

**Key emissions:**

1. **Emission to air** – the wet zircon concentrate will be heated and dried using fluidized bed dryers and reheaters, prior to being screened and fed to an electrostatic circuit. Waste gases from the dryers will pass through a baghouse (fabric filter) to remove particulate matter, prior to discharge to the atmosphere via a 30 m stack.
2. **Emission to air** – the DZP contains a dust collection system, which collects fine dust particles from selected material/equipment transfer points. Particulates will be scrubbed from the system (wet spray), prior to discharge to the atmosphere via a 30 m stack.
3. **MSP rejects** – conductors from the first five HTR stages report to an additional HTR stage, where any remaining conductors at this point of the process report to a reject bin.
4. **MSP rejects** – non-conductors from the first five HTR stages pass through a single stage of rare earth roll magnets (RER), with the magnetics reporting to a second stage of RERs, where any remaining magnetics at this point of the process report to a rejects bin.

Ilmenite Dry Plant

The IDP will receive magnetic concentrate from the CUP and the HAL, and will separate the conductive material (ilmenite) from the non-conductive material (impurities) using HTRs. The ilmenite-bearing conductors will be fed to the low temperature roaster (LTR).

**Key emissions:**

1. **Emission to air** – the magnetic concentrate is firstly dried through fluidized bed dryers and reheaters, prior to electrostatic separation using HTRs. Waste gases from the dryers will pass through a baghouse (fabric filter) to remove particulate matter, prior to discharge to the atmosphere via a 30 m stack.
2. **Emission to air** – the IDP contains a dust collection system, which collects fine dust particles from selected material/equipment transfer points. Particulates will be scrubbed from the system (wet spray), prior to discharge to the atmosphere via a 30 m stack.
3. **MSP rejects** – non-conductors report to a rejects stockpile.

Ilmenite Low Temperature Roaster

The ilmenite concentrate will be roasted in a controlled gas atmosphere to selectively enhance the magnetic separation characteristics of the ilmenite, so it can be easily separated from less magnetic, deleterious gangue minerals, such as chromite. This will produce an upgraded ilmenite ('***LTR ilmenite***') product amenable to manufacture of sulfate pigment, chloride pigment and/or use within production of titanium slag by smelting.

**Key emissions:**

1. **Emission to air** – the crude ilmenite concentrate will be pre-heated, prior to entering the LTR fluid bed reactor. Pre-heating off-gas will be quenched in a venturi scrubber and pulled through an induced draft fan for release to the atmosphere via a 60 m stack.

Ilmenite Magnetic Separation

The magnetic iron oxides will be separated from the roasted ilmenite concentrate by means of dry low intensity magnetic separators (LIMS). The magnetic stream reports to a rejects stockpile and will be stored as a '***titano-magnetite***' product, whilst the non-magnetic stream reports to higher intensity RERs. The magnetic stream from the RERs will be stored as an '***ilmenite***' product.

**Key emissions:**

1. **MSP rejects** – non-magnetics from the RERs will be combined with magnetics from the LIMS and report to a rejects stockpile.

### 4.2.4 Ancillary storage and handling plants

Acid/caustic storage and handling

Concentrated sulfuric acid (98 %wt) and caustic soda solution (sodium hydroxide, 50 %wt) will be delivered by tanker trucks and pumped into storage tanks. Dosing pumps will draw the acid/caustic from the storage tanks and deliver to the HAL plant. The concentrated sulfuric acid/caustic dosing streams will be diluted with process water prior to being fed into the HAL reactors and attritioners, respectively.

The acid storage plant and caustic plant will each incorporate a bunded area for acid/caustic delivery and another for the storage, dosing pumps and equipment. Each area will have a sump and sump pump.

Lime plant

Hydrated lime will be delivered by bulk carrier trucks and blown into a bulk storage bin that incorporates a dust collector to allow for venting during the filling operation. A variable speed metering screw feeder will feed lime powder into a mixing tank where water will be added to produce a "milk of lime".

The milk of lime will be pumped into a small thickener, which will also receive streams from sump pumps for the acid and caustic plants as well as the bunded area for the lime storage plant.

**Key emissions:**

1. **Discharge to land** – milk of lime will be added to form gypsum, which will settle and be pumped out as underflow to the co-disposal sump.
2. Neutralised overflow will be pumped to the WCP process water dam (along with the CUP clarifier overflow) to be reused as circuit water.

### 4.2.5 Tailings management

Tailings will be managed via co-disposal, which will involve mixing the coarse and fine tailings streams, prior to disposal into the mine void. Initially, it is proposed to store tailings within a conventional above-ground TSF. Once there is sufficient mine void storage capacity all further tailings will be returned to mine voids as backfill.

**Key Findings:**

1. Tailings management and disposal has not been included within the scope of this Application, and will be assessed under a separate works approval application.

### 4.2.6 Mine water management

Groundwater levels over the Thunderbird deposit are in excess of 20 mbgl over most of the Premises, with the majority of mining occurring above the water table. When mining above the water table, drainage sumps will be located in the floor of the pit to recover in-pit seepage and stormwater runoff. Recovered water from within the pit will be kept within a closed process water circuit for re-use in the mining and processing operations.

Dewatering of the mine area is predicted to be required from approximately Year 15, initially enabling mine dewater to replace water abstracted from the purpose built borefield for use in the processing plants. Hydrogeological modelling indicates there will be a positive water balance by Year 32, where it is proposed a portion of the abstracted water will be re-injected into the Broome Sandstone downgradient of mining operations.

**Key Findings:**

1. Active dewatering is not expected to be required for the first 15 years of mine operations, as mining will be conducted above the natural water table.
2. Dewatering management and disposal of excess mine water has not been included within the scope of this Application, and will require assessment under a future works approval or licence.

Although tailings management has not been included within the scope of this assessment, water will also drain from mineral stockpiles and other areas where the partially saturated co-disposal stream is deposited (i.e. return water from the initial TSF/mine void and deslimed ore/HMC stockpiles). Where possible, this water will be captured and recycled via the process water dams to supplement the mine water demand.

Table 8 summarises the predicted high-level water balance for the site based on steady state operation (Year 4+) and prior to dewatering below-water table ore (Year 15+). The water balance model will be refined based on actual site experience and seasonal conditions. A conceptual schematic of water inputs and outputs, including operations for obtaining process water is shown in Figure 4.

**Table 8: Proposed water balance**

| Water in | Volume | | Water out | Volume | |
|---|---|---|---|---|---|
| | **$m^3/h$** | **$GL/a^2$** | | **$m^3/h$** | **$GL/a^2$** |
| MUP feed | 72.1 | 0.537 | Mining void losses | 133.9 | 0.997 |
| Raw water supply[1] | 519.9 | 3.871 | TSF seepage | 325.2 | 2.421 |
| | | | TSF evaporation | 78.6 | 0.585 |
| | | | TSF excess water | 38.6 | 0.287 |
| | | | Dryer losses | 9.0 | 0.067 |
| | | | Water treatment plant | 6.0 | 0.045 |
| **Total water in** | **592.4** | **4.408** | **Total water out** | **591.3** | **4.403** |

Note 1: Sourced from the Broome aquifer production borefield.
Note 2: Based on 7,446 operating hours.

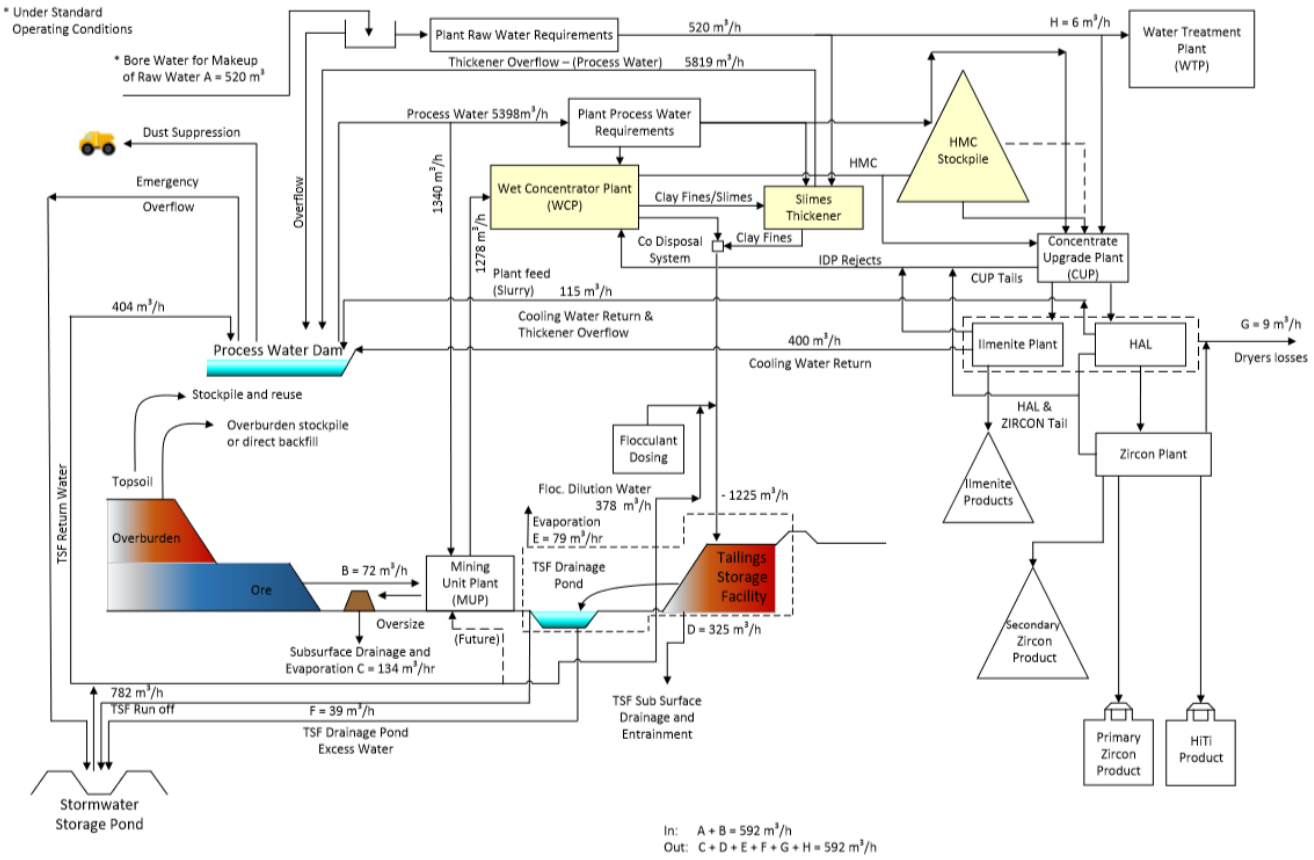


***Figure 4: Mine water circuit for the proposed mine***

### 4.2.7 Water distribution network

The proposed water distribution network begins by transferring water abstracted from the Broome aquifer via production bores to a central storage and transfer pond, from where it will be distributed to processing facilities and associated activities. Water recovered from active mine voids will supplement usage from the Broome aquifer.

**Water storages**

Water storage ponds will be constructed for the WCP with capacities of 40,000 kL and 15,000 kL, respectively. Two x 6,380 kL settling ponds will also be constructed to facilitate recycling of WCP process water (Table 9).

**Table 9: Mine site water storages**

| Water storage | Input source | Size | Purpose |
|---|---|---|---|
| Central storage and transfer pond | Borefield | 100 x 200 x 2 m<br>40,000 kL | Regulation of the water management system |
| WCP process water pond | Borefield, overflow from the WCP settling pond | 76 x 82 x 3.5 m<br>15,000 kL | MUP and wet process plant use |
| WCP settling ponds | Decant water from mining void, TSF | 80 x 82 x 2.2 m<br>13,080 kL | Wet process plant use, overflow is to the WCP process water pond |

The ponds will be constructed in in-situ material and excavated below the ground surface. All ponds will be lined with 1.0 mm HDPE.

**Surface water management**

The mine site is located on sandy soils with low runoff generation, however during extreme rainfall events some surface water flows may occur that require surface drainage.

Surface water diversion bunds and drains and evaporation/sediment traps will be installed to contain runoff generated by a 1:50 year, 72 hour rainfall event (approximately 400 mm rainfall over 72 hours). Runoff from disturbed areas will be channeled to a stormwater (first flush) pond, where possible.

Drainage from disturbance areas around the process plant area will be directed to evaporation/sediment traps, prior to reporting to a purpose-built stormwater (first flush) pond.

## 4.3 Operational aspects – Sewage treatment plant

The sewage treatment plant has been sized to deal with wastewater generated by the 300 workers during the initial a two year construction period, which requires a maximum treatment capacity of 100 $m^3$/d. The plant will be operated at a lower capacity following the construction period for the 180 permanent workers over the remainder of the life-of-mine.

Each system will treat influent using the four-stage “Bardenpho” process, which uses multiple tank zones operated in anaerobic, anoxic and aerobic modes. The treatment process essentially comprises: influent screening, balance tank mixing, anaerobic, anoxic and aerobic treatment, clarification, effluent sterilisation (chlorine tablets) and bag filtration (Figure 5 and Figure 6).

Tanks will be equipped with hydrostatic level transducers and when the water level reaches set limits, it will start the forward pumps to transfer water from one tank to another when required and also to prevent overflow while maintaining treatment time. Other transfer infrastructures such as treated effluent pipeline to irrigation fields will run above ground to detect leaks and blockages and it will only be buried where it crosses roads etc. Other management controls include overflow alarms and remote monitoring and control capabilities.

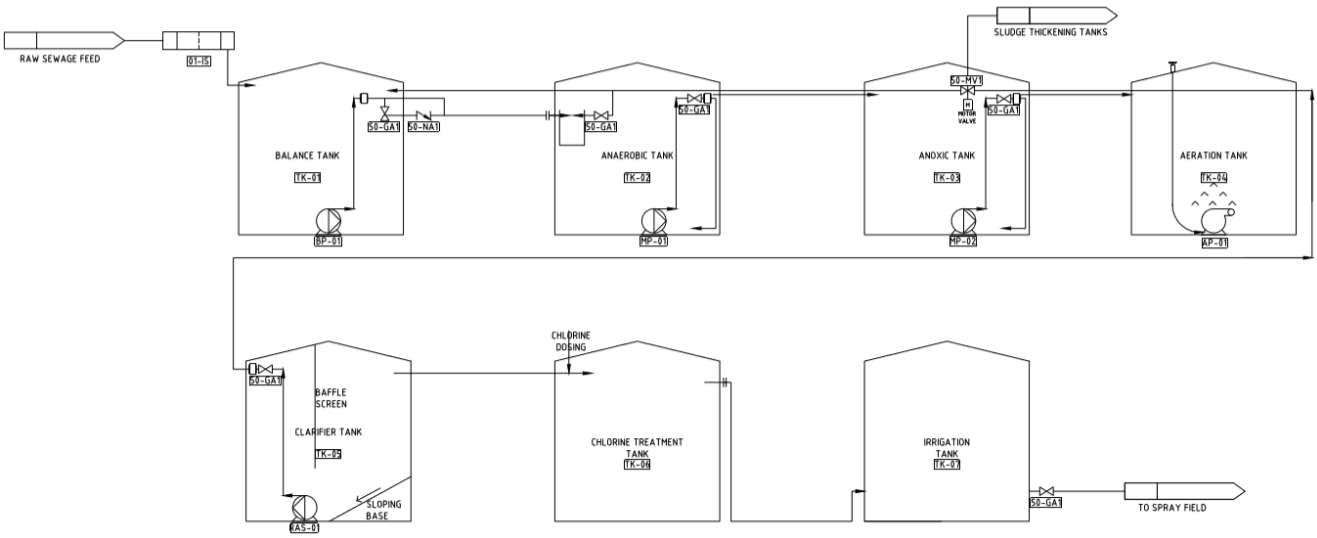


***Figure 5: Sewage treatment plant process (Bardenpho process)***

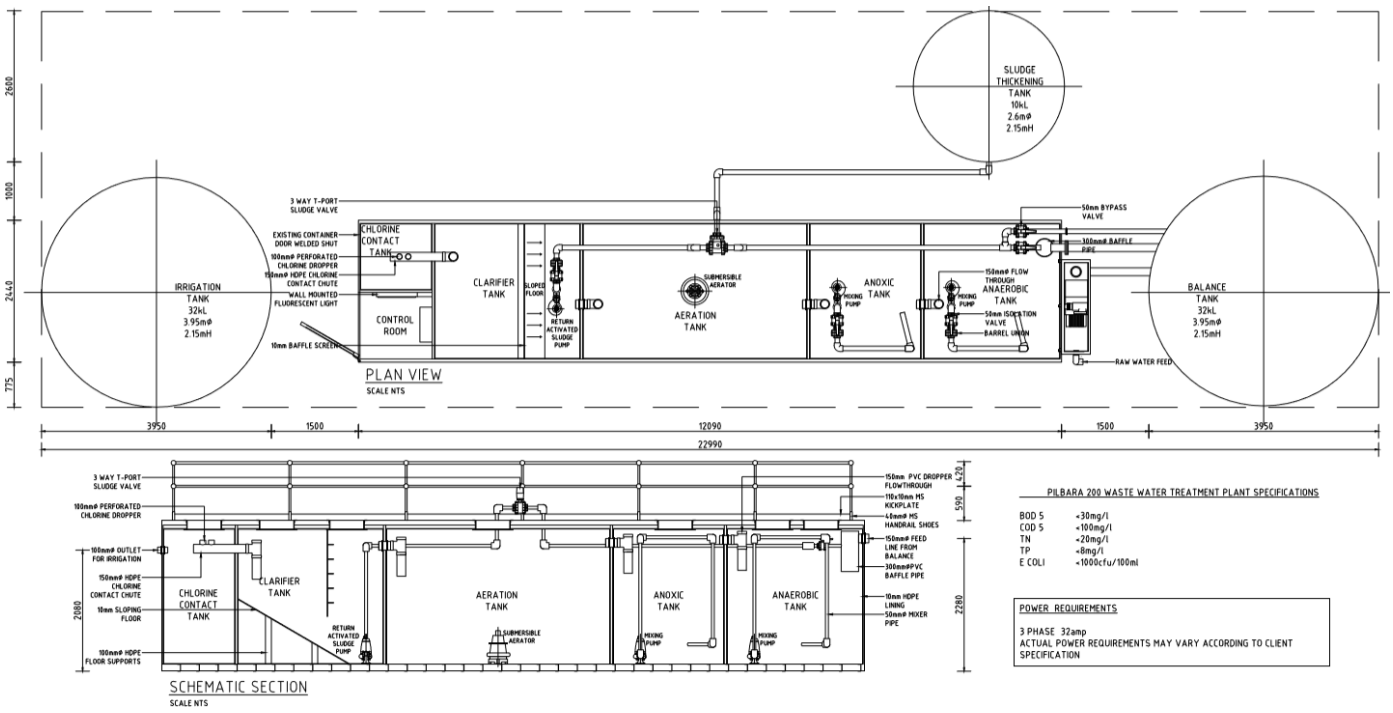


***Figure 6: Sewage treatment plant – plan view***

### 4.3.1 Irrigation of effluent

The Applicant proposes to discharge treated effluent over a dedicated irrigation spray field located approximately 250 m south of the worker's accommodation camp. The spray field will cover 23.0 ha (48 m x 480 m) and is sized in accordance with the nutrient loadings for a maximum of 500 workers.

The irrigation spray field comprises native vegetation (hummock grassland and shrubs) that forms part of the area authorised for clearing; however the vegetation will not be physically cleared. Chlorinated and treated effluent will be discharged via a number of hammerhead impact sprinklers to achieve a spray radius of approximately 15 $m^2$ per sprinkler. The spray field will be operated on a rotational basis to ensure that irrigation does not cause water logging or uneven distribution of nutrients.

The hammerhead impact sprinkler head will deliver large droplets of water directly on the ground without causing misting or unwanted overspray outside of the dedicated spray field. Irrigation will occur automatically, using level floats in the irrigation tanks. The hydraulic application rate will be in the order of 0.7 mm/day to prevent pooling or ponding.

### 4.3.2 Sludge and screened waste disposal

Screened materials from the influent will be collected in a bag at the bottom of the chute, to enable the waste to be dewatered. The bag of dry waste will then be removed for disposal to the landfill. A controlled waste contractor will be engaged periodically to remove sludge from the sludge tank, for off-site disposal. The Applicant estimates this will occur once or twice per year, depending on the number of workers.

## 4.4 Operational aspects – Landfill

The landfill will be operated by placing waste into cells and covering with excavated materials to serve as a capping layer between waste cells. The amount of waste requiring disposal over the life-of-mine has been calculated by the Applicant as 43,800 $m^3$.

## 4.5 Infrastructure

The proposed infrastructure, as it relates to Category 8, 54 and 89 activities, is detailed in Table 10 and with reference to the Site Plan (attached in the Issued Works Approval).

**Table 10: Thunderbird Stage 1A infrastructure**

| **Infrastructure** | |
|---|---|
| **Prescribed Activity Category 8** | |
| Mining of heavy mineral sands from the Thunderbird deposit up to a depth of approximately 100 m below ground level over a 40 year period, including on-site primary and secondary processing of ore to produce a range of saleable mineral sands products | |
| 1 | Mining fleet:<br>Dozer – 2 x D11, 1 x D10, 1 x D9<br>Front End Loader – 1 x CAT 992K<br>Excavator – 1 x 100T Komatsu PC1250<br>Haul Truck – 4 x CAT 7776<br>Grader – 1 x CAT 16M<br>Scraper – 4 x CAT 657G<br>IT Loader - 1 x CAT IT62<br>Rockbreaker – 1 x CAT 330<br>Watercart – 2 x CAT 740 |
| 2 | Overburden and topsoil/subsoil stockpiles |
| 3 | 1 x 810 t/hr skid-mounted dozer trap MUP |
| 4 | Mine water storages, including:<br>- 1 x 40,000 kL central storage and transfer pond (inflow from borefield)<br>- 1 x 20,000 kL WCP process water pond (borefield and overflow from WCP settling dam)<br>- 1 x 20,000 kL WCP settling pond (decant water from mining void/TSF)<br>- 1 x 5,000 kL MSP process water pond (WCP process water pond for raw water, CUP thickener overflow) |
| 5 | 2 x Wet Concentrator Plants, each comprising:<br>- 1 x HMC stockpiling area<br>- 1 x coagulant plant<br>- 1 x flocculant plant and flocculant dilution pump skid |

| Infrastructure | |
|---|---|
| | - 1 x WCP, consisting of:<br>  - feed preparation plant, which produces a de-slimed material for further processing, consisting of a transfer bin, desliming cyclones and surge bin c/w slurry pumps<br>  - gravity separation plant, which removes +425 µm oversize and sand tails to produce a HMC which is stockpiled at the MSP. The plant will consist of spirals, distributors and transfer bins c/w slurry pumps<br>  - co-disposal plant, which combines the sand tails and thickened slimes for disposal back to the mine void. The plant will consist of a high rate thickener, cyclones, distributors and transfer bins c/w slurry pumps<br>  - process water storage and distribution system, which locally screens, stores and distributes process water to the WCP and MUP field water bin<br>  - process water supply and field reclamation system, which delivers process water to the WCP from the WCP process water dam, and recovers water from the co-disposal tailings area for reuse. The mechanical assets will include:<br>  - 2 x water delivery pumps and distribution network<br>  - 1 x field co-disposal switching skid<br>  - 2 x field co-disposal mixing skids<br>  - 2 x field slurry pipe flushing valve skid<br>  - 3 x tails decant return water diesel pumps |
| 6 | 2 x Mineral Separation Plants (MSP), each comprising:<br>- 1 x sulfuric acid storage and handling plant<br>- 1 x caustic soda storage and handling plant<br>- 1 x lime storage and handling plant<br>- Concentrate Upgrade Plant (CUP), consisting of:<br>  - magnetic and gravity separation equipment, which produces magnetic and non-magnetic concentrates, pumped to dewatering stockpiles<br>  - process water storage and distribution system, which locally screens, stores and distributes process water at the CUP<br>- CUP intermediate stockpiling areas, consisting of:<br>  - dewatering stockpile for non-magnetic concentrate<br>  - short-term dewatering stockpile for magnetic concentrate<br>  - long-term dewatering stockpile for magnetic concentrate<br>Hot Acid Leaching Plant (HAL), consisting of:<br>  - fluid bed dryers and re-heaters<br>  - acid leaching and gravity separation plant, which cleans up and removes iron stain from the non-magnetic concentrate<br>  - process water storage and distribution system, which screens and stores process water for local HAL distribution<br>- Zircon Separation Plant (ZSP), consisting of:<br>  - fluid bed dryers and re-heaters<br>  - electrostatic and magnetic separation equipment, which separates conductors from non-conductors<br>  - dust collection system, which collects fine dust particles from selected material/equipment transfer points from within the ZSP<br>  - humidity control system, required to regulate the humidity at each of the high tension electrostatic roll separator feed boxes<br>- Zircon Processing Plant, consisting of:<br>  - Wet Zircon Plant (WZP), which upgrades the zircon concentrate by removing tails, prior to further processing<br>  - WZP process water storage and distribution system, which screens and stores process water for local WZP distribution<br>  - Dry Zircon Plant (DZP), including fluid bed dryers and re-heaters, which uses electrostatic and magnetic equipment to produce a primary zircon<br>  - DZP dust collection system, which collects fine dust particles from selected material/equipment transfer points from within the DZP |

| Infrastructure | |
|---|---|
| | - Ilmenite processing facility, consisting of:<br>- Ilmenite Dry Plant (IDP), including a fluid bed dryer, which uses electrostatic equipment to produce a low TiO2 ilmenite concentrate for further processing at the Low Temperature Roast (LTR)<br>- IDP dust collection system |
| 7 | Process water system (PWS), which delivers process water to the CUP/HAL/WZP/LTR from the MSP process water pond, including:<br>- 1 x HAL water delivery pump and distribution pipework<br>- 1 x WZP water delivery pump and distribution pipework<br>- 2 x LTR water delivery pumps and distribution pipework, setup in a duty and standby arrangement<br>- 1 x CUP slimes thickening plant (incl. thickener underflow pump and distribution pipework)<br>The PWS will be located in three areas:<br>1. Mining void (initially at off-path TSF), comprising a flocculant plant for co-disposal stream and diesel powered tails return water decant pump<br>2. Adjacent to the WCP, comprising a WCP settling pond, process water pond, MSP process water pond and process water supply pumps<br>3. Adjacent to the MSP, comprising CUP thickener and CUP thickener underflow pump, overflow from the CUP thickener supplies process water to the CUP, process water supply pump for the HAL and WZP and make-up water supply from the borefield to the acid, sulfate and lime storage plants |
| 8 | Pipeline network, including:<br>Water pipelines:<br>- from the borefield to the central storage pond and transfer pond<br>- from the central storage pond and transfer pond to the worker's accommodation camp<br>- from the central storage pond and transfer dam to the processing plant<br>- potable water pipeline from the water treatment plant to the process plant and mining area<br>- from the WCP process water dam to a field tank that will feed the MUP wet scrubber and ore slurrying<br>Mining pipelines:<br>- ore slurry pipelines from the MUP in the active mine voids to the WCP<br>- water pipeline from the WCP to the MUP field tank<br>- water pipelines from in-pit sumps to the MUP field tank<br>- water pipelines from backfilled cells to the WCP settling pond<br>Effluent pipelines:<br>- from the worker's accommodation camp to the WWTP<br>- from the mining area to the WWTP<br>- from the processing plant to the WWTP<br>- treated effluent from the WWTP to the irrigation spray field |
| 9 | Initial off-path Tailings Storage Facility (TSF) |
| 10 | Surface water drains and diversions, including:<br>- WCP drain – capturing runoff from WCP areas with water directed to sumps<br>- MSP drain – capturing runoff from MSP areas (including processing stockpiles) with water directed to sumps<br>- Pit bund – minimising surface flow into the active mine void, with the location moving as the active mining area changes over time |
| **Prescribed Activity Category 54** | |
| Activated sludge bioreactor-type packaged sewage treatment plant with a design capacity of 100 $m^3$/d to service the worker's accommodation camp (max 300 people). Treated wastewater to be | |

| Infrastructure | |
|---|---|
| discharged to an irrigation spray field | |
| 1 | 2 x self-contained, modular treatment plants, consisting of influent screening, balance tank mixing, anoxic & aerobic treatment, clarification, effluent sterilisation (chlorine tablets) and bag filtration (100 micron) |
| 2 | Treated effluent tank (66 $m^3$) |
| 3 | Irrigation spray field (23 ha) comprising native vegetation |
| 4 | PVC pipework linking the camp to the WWTP and to the irrigation spray field |
| **Prescribed Activity Category 89** | |
| Putrescible landfill site for disposal of domestic waste generated from the worker's accommodation camp. Below ground trench design (unlined) covering an area 200 m x 400 m to dispose up to 43,800 $m^3$ over the life-of-mine | |
| 1 | Landfill area – 220 x 400 x 4 m (trench system) |
| 2 | Boundary fence/litter screen |
| **Other activities** | |
| 1 | Groundwater abstraction (12.2 GL/a) for potable water supply, ore processing and general mine use (incl. dust suppression) |
| 2 | Water treatment – filtration and chlorination using a multi-media filtration system, designed to produce 100 $m^3$/d potable water |

## 4.6 Exclusions to the Premises

The following matters are out of the scope of this assessment and have not been considered within the technical risk assessment detailed in this Decision Report:

- worker's accommodation camp;
- contractor's laydown yards, maintenance areas and mechanical workshops, equipment storage areas, wash down bays, etc.;
- fuel storage and re-fuelling area(s);
- bioremediation area(s); and
- rehabilitation.

The Works Approval is related to Category 8, 54 and 89 activities only and does not offer the defence to offence provisions in the EP Act (see s. 74, 74A and 74B) relating to emissions or environmental impacts arising from non-Prescribed Activities, including those referenced above.

# 5. Legislative context

Table 11 summarises approvals relevant to the assessment.

**Table 11: Relevant approvals and tenure**

| Legislation | Number | Approval |
|---|---|---|
| Part IV of the EP Act | Ministerial Statement 1080 | Ministerial approval for implementation of the proposal (to construct and operate the Thunderbird mine) |
| *Mining Act 1978 (WA)* | N/A – pending submission of Mining Proposal | Mining approval required to commence mining on M04/459 |
| *Rights in Water and Irrigation Act 1914 (WA)* | CAW 021251(1) | Approval to construct 15 production bores in the Canning-Kimberley Groundwater Area, Canning-Broome aquifer |
| *Environment Protection and Biodiversity Conservation Act 1999 (Cth)* | Decision Notice EPBC 2016/7648 | The proposed action (to construct and operate a heavy mineral sands mine) is a controlled action, and requires assessment and approval under the EPBC Act before it can proceed |

## 5.1 Part IV of the EP Act

### 5.1.1 Background

The original mine proposal was referred to the EPA in November 2015 under s. 38 of the EP Act. In December 2015 the EPA decided to assess the proposal and set the level of assessment at Public Environmental Review (PER) with a four week public review period (EPA Assessment No. 2073), with the proponent to prepare the Environmental Scoping Document (ESD).

The EPA approved the ESD for the proposal in July 2016. The PER document was released for public review from 16 January 2017 to 13 February 2017, with a total of 52 submissions received. Issues raised on the proposal included:

- managing impacts on terrestrial fauna, in particular the Greater Bilby;
- managing impacts on groundwater and surface water;
- rehabilitation of flora and vegetation, and habitat for fauna;
- consultation with Traditional Owners; and
- cumulative impacts in the Kimberley Region, in particular the Dampier Peninsula.

The EPA released its final report on the assessment (EPA Report 1606) in October 2017. A total of six appeals were subsequently lodged in objection to the contents and recommendations of the report, with the key issues relating to potential environmental impacts to fauna, flora and vegetation, Aboriginal heritage, hydrological processes and inland waters environmental quality, greenhouse gas emissions, rehabilitation, offsets, and the EPA assessment process.

The Minister allowed in part the appeals in June 2018, to the extent the recommended conditions under Part IV of the EP Act include the requirement to make publicly available all validated environmental data; however otherwise dismissed the appeals in respect to the EPA's report and recommendations.

The project was approved by the Minister in August 2018 through the issuing of Statement 1080.

### 5.1.2 Minor or preliminary works

In June 2017, the Applicant sought the EPA's consent to undertake minor or preliminary works under Section 41A(3) of the EP Act, relating to the mining and processing of 370,000 tonnes of material over an estimated 12 week period from two test pits for further geotechnical testing. On 27 July 2017 the EPA consented to the preliminary works, on considering the limited nature and disturbance (22 ha) of the works in comparison to the main Project proposal (1,635 ha).

## 5.2 Other relevant approvals

### 5.2.1 *Mining Act 1978*

With the exception of land alienated before 1 January 1899, all minerals[1] are the property of the Crown, and a mining title must be obtained from the Department of Mines, Industry Regulation and Safety (DMIRS) before ground disturbing exploration activities or any mining operations may be undertaken (DMP, 2015). The Applicant is yet to submit a mining proposal to DMIRS, as the tenure for Mining Lease 04/459 is pending[2], subject to a native title process.

DMIRS also administer the Mines Safety and Inspection Act 1994, with respect to the standards for occupational safety and health. The Resources Safety Division administers occupational health (OSH) legislation for mining operations, and safety legislation and the licensing regime for dangerous goods, including regulation of the State's major hazard facilities. This includes the requirement to lodge and have approved a Project Management Plan, reviewing structural designs and specifications of tailings storage facilities and other engineered mine-related infrastructure, etc.

### 5.2.2 *Rights in Water and Irrigation Act 1914 (WA)*

Groundwater is a key component of the mining operation and will be used in various mining and processing facilities across the site, including potable water supply.

The Premises lies within the Canning-Pender sub-area of the Canning-Kimberley Groundwater Area, which encompasses the majority of the Dampier Peninsula (excluding the area near Broome) and has approximately 95% of its available groundwater resources available for allocation (DoW, 2010).

Groundwater abstraction in gazetted areas is regulated by DWER under section 5C of the RIWI Act. A Licence to Construct or Alter a Well has recently been issued to allow the Licence Holder to construct 15 bores to establish their production bore network, in addition to installing additional monitoring bores. Pump testing analysis of the new bores will be required to confirm the production borefield capacity.

### 5.2.3 *Radiation Safety Act 1975 (WA)*

Deposits of mineral sands contain levels of naturally occurring radioactive materials (NORM). The radioactive constituents are mostly thorium with smaller amounts of uranium, and their respective decay products. Monazite is the most common radioactive mineral and typically constitutes less than 0.5% of the mined ore; however any operation in which radioactive containing material is extracted from the ground and processed can potentially concentrate

[1] When occurring on private land, the following are not considered minerals for the purposes of the Mining Act: limestone, rock, gravel, shale, sand and clay (excluding oil shale, mineral sands, silica or garnet sand, kaolin, bentonite, attapulgite and montmorillonite).

[2] A mining proposal cannot be submitted to DMIRS until the tenure it relates to is 'live'.

NORM in product, by-product or waste streams.

The management of radiological risk (to human health and the environment) from NORM is undertaken jointly by DMIRS and the Radiological Council of WA (RCWA). Prior to the commencement of any stage of mining to which radiation regulations apply, the Applicant is required to obtain approval for a Radiation Management Plan (RMP) and a Radiation Waste Management Plan (RWMP) for the proposed activities at that stage. Both plans are reviewed by DMIRS and RCWA against defined requirements before the grant of approval to operate.

### 5.2.4 Planning approvals

The Shire of Broome (Shire) has advised that under s. 120 of the Mining Act, development approval under the *Shire of Broome Local Planning Scheme No.6* is not required for the mining operation, including the workers accommodation camp and other infrastructure incidental to mining operations.

The proposed sewage facility at the workers accommodation camp requires approval from the Department of Health, with the application to be lodged with the Shire.

### 5.2.5 *Environment Protection and Biodiversity Conservation Act 1999 (Cth)*

The mine proposal was determined to be a controlled action by a delegate of the Commonwealth Minister for the Environment under the EPBC Act in April 2016 as it will, or is likely to have, a significant impact on the following Matters of National Environmental Significance:

- Listed threatened species and communities (s. 18 and 18A).

The proposal was assessed under the Bilateral Agreement relating to environmental assessment (2014) between the Commonwealth and Western Australian governments.

## 5.3 Part V of the EP Act

### 5.3.1 Applicable regulations, standards and guidelines

The overarching legislative framework of this assessment is the EP Act and EP Regulations. The guidance statements which inform this assessment are:

- *Guidance Statement: Regulatory Principles (July 2015)*;
- *Guidance Statement: Setting Conditions (October 2015)*;
- *Guidance Statement: Licence Duration (August 2016)*;
- *Guidance Statement: Environmental Siting (November 2016)*;
- *Guidance Statement: Decision Making (February 2017)*; and
- *Guidance Statement: Risk Assessment (February 2017).*

### 5.3.2 Clearing of native vegetation

Clearing of native vegetation in Western Australia requires a clearing permit, unless exemptions apply. Under Schedule 6 of the EP Act, clearing assessed under s. 40 as part of a proposal referred under s. 38 does not require a clearing permit, providing the clearing is done in accordance with the Implementation Agreement or Decision.

The EPA has assessed the clearing of remnant vegetation within areas to be mined and clearing for access roads, etc. The authorised extent of clearing has been limited to a maximum of 1,635 ha for mine pits and 326.1 ha for processing and supporting infrastructure, respectively, within a 5,648 ha mine site development envelope.

# 6. Modelling and monitoring data

## 6.1 Acid sulfate soils

The Applicant has conducted geochemical characterisation of mine waste samples (MBS, 2016) to verify whether acid sulfate soils (ASS) are present based on soil characteristics. A total of 57 samples from 16 drill holes were taken across the defined resource and proposed mining area for the full life-of-mine, and comprising overburden (13 samples), mineralised waste above the orebody (15), orebody sands (12), mineralised waste below the orebody (14) and basement bed samples (3).

### 6.1.1 Results

The key results from the soil sampling and associated laboratory testing for acid-base accounting include:

- Total sulfur concentrations were ≤ 0.03% in 96% of samples (55 of 57 samples), and classified as Non-Acid Forming (NAF) – barren, having neither acid forming or acid neutralising capacity; and
- The two deepest samples, at or below 53.5 m below the natural water table (approx. 88.5 m below ground level [m bgl]), contained 0.22% and 0.96% S, respectively and were classified as Potentially Acid Forming (PAF). These samples were identified as basement material or mineralised waste below the orebody and are not intended for excavation.

The results indicate that mine waste at depths less than 48.5 m below the natural water table (approx. 83.5 m bgl) will be NAF and barren with no capacity for acid generation or acid neutralisation.

As PAF material was found to occur at depths between 48.5 m (non-sulfidic) and 53.5 m (sulfidic) below the natural water table, further confirmation of the depth and extent of this sulfidic material is required. The Applicant therefore proposes to develop an appropriate mining strategy and ASS management plan before any possible disturbance of material at this depth occurs, including consideration of the cone of depression resulting from mine dewatering.

### 6.1.2 DWER technical review

DWER's review of the *Mine Waste Characterisation* report (MBS, 2016) provided as part of the Application identified that:

- The assessment was carried out in an appropriate manner and based on the results the risk of ASS disturbance above the natural water table is low; and
- It is recommended the Applicant develops an appropriate mining strategy and ASS management plan well in advance of mining commencing below the natural water table.

# 7. Consultation

The Application was referred to the holder of the Mt Jowlaenga and Yeeda Pastoral Leases, in addition to several direct interest public authorities and traditional landowner groups. A summary of responses is provided in Table 12.

**Table 12: Direct interest stakeholder submissions and DWER consideration**

| Submitter | Comment |
|---|---|
| Department of Mines, Industry Regulation and Safety | Nothing further to add to comments made previously for W6072/2017/1. |
| Department of Biodiversity, Conservation and Attractions | Nothing further to add to comments made previously for W6072/2017/1. |
| Shire of Broome | In consideration of s.120 of the Mining Act, development approval is not required from the Shire for mining operations on mining tenement.<br>The Shire advises the wastewater treatment plant will require approval under the Health Act (through the Shire).<br>Given the above, the Shire of Broome raises no objections to the application. |
| Traditional Landowner groups | No submission received. |
| Pastoral lease holder | No submission received. |

# 8. Location and siting

## 8.1 Siting context

The Premises is located on the western Dampier Peninsula in the State's Kimberley region, approximately half way between Derby and Broome.

The site is located within the Mt Jowlaenga Pastoral Lease, a large cattle grazing property characterised by sandplains and dunes with scattered hills and spinifex grassland. Access to the site is from the Great Northern Hwy via a 32 km long site access road.

## 8.2 Residential and sensitive Premises

The identified nearest potential sensitive receptors to the mine site are detailed in Table 13.

**Table 13: Receptors and distance from activity boundary**

| Sensitive Land Uses | Distance from Prescribed Activity |
|---|---|
| Thunderbird worker's accommodation camp[1] | Approx. 5 km from the proposed mine site |
| Mt Jowlaenga homestead[2] | Approx. 7 km from proposed mine site |
| Nillibubbica designated rest area, Great Northern Hwy | Approx. 27 km from proposed mine site |
| Bidan (formerly known as Bedunburra) Aboriginal Community | Approx. 28 km from proposed mine site |
| Yeeda Outstation, Mt Jowlaenga Rd | Approx. 28 km from proposed mine site |

Note 1: Not considered as potential receptors in accordance with DWER's *Guidance Statement: Risk Assessments* (DER, 2017).

Note 2: Currently unoccupied, but may be reopened.

## 8.3 Specified ecosystems

Specified ecosystems are areas of high conservation value and special significance that may be impacted as a result of activities at or Emissions and Discharges from the Premises. The distances to specified ecosystems are shown in Table 14. Table 14 also identifies the distances to other relevant ecosystem values which do not fit the definition of a specified ecosystem. The table has also been modified to align with the *Guidance Statement: Environmental Siting.*

**Table 14: Environmental values**

| **Specified ecosystems** | **Distance from the Premises** |
|---|---|
| Ramsar Sites in Western Australia | The closest site is Roebuck Bay, approximately 90 km south-west of the Premises |
| Important wetlands – Western Australia | The closest wetlands suite is the Roebuck Plains System, approximately 40 km south of the Premises |
| Parks and Wildlife Managed Lands and Waters | The closest is Coulomb Point Nature Reserve, approximately 60 km west of the Premises |
| Threatened Ecological Communities (TECs) and Priority Ecological Communities (PECs) | The closest mapped TECs are located along the coastline, approximately 80 km west of the Premises, including the Roebuck Bay mudflats,<br>The closest mapped PECs include the Lowangan Land System (21 km east); Vegetation Association 67 (35 km south and north) |
| **Biological component** | **Distance from the Premises** |
| Threatened/Priority Flora | No declared rare or threatened flora pursuant to the WC Act or EPBC Act have been recorded within M04/459<br>Two Priority flora species have been recorded within M04/459 (none within the preliminary works footprint) |
| Threatened/Priority Fauna | Fauna surveys identified a number of conservation significant fauna species that have the potential to occur within M04/459 and surrounds<br>Nine conservation significant fauna species were recorded in the wider survey area, with 3 recorded within M04/459, including the Greater Bilby, the Short-tailed Mouse and the Rainbow Bee-eater<br>During a targeted Greater Bilby survey, over 750 records of Greater Bilby activity were recorded within proximity to M04/459 |

## 8.4 Physiography and climate

### 8.4.1 Physiography and drainage

The Premises is located on sandy plains, including Pindan silty sand, with some areas of sandstone outcrop and irregular sand dunes.

The majority of the Premises lies within the Fraser River South catchment, and extends into the greater Fraser River catchment. The site access road crosses the Logue and Little Logue River catchments. There are no declared surface water areas within the Premises or the Logue/Fraser River catchments.

### 8.4.2 Rainfall and evaporation

The Premises is situated within a tropical monsoon climate region, where 90% of the region's rainfall falls during a short wet season, from November to April, when cyclones are common and the rivers flood. Average annual rainfall is between 250 – 800 mm per year (Figure 7),

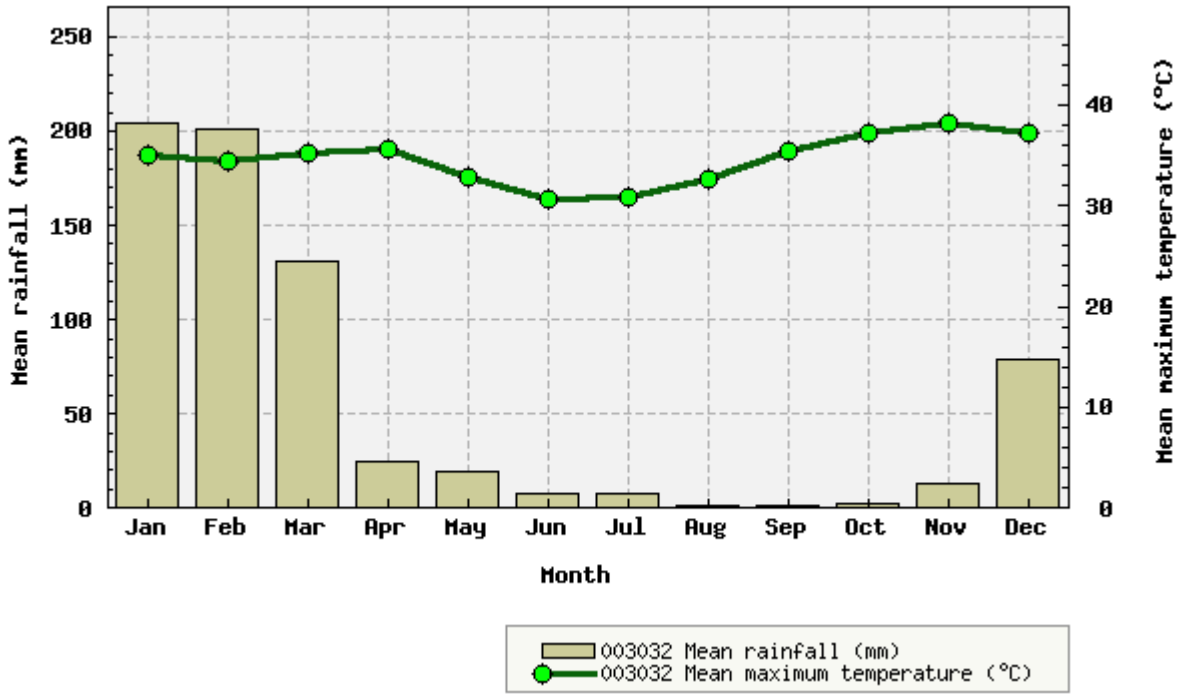


***Figure 7: Average rainfall and maximum temperature for Derby Aero 1951 – 2018***

with the heaviest and most widespread falls associated with thunderstorms.

Evapotranspiration varies moderately across seasons, however generally remains higher than rainfall, averaging 1,980 mm per year, even in the wet season.

### 8.4.3 Vegetation

Mattiske (2016) notes the majority of the Premises comprises red sandy flats supporting pindan[3] vegetation, which is common and widespread through the broader Kimberley region.

No threatened flora has been recorded during vegetation surveys within the Premises. The priority taxon *Triodia caelestialis* (P3) has been recorded widely across the Premises, whilst a second priority taxon *Pterocaulon intermedium* (P3) has been recorded infrequently, and not associated with any specific landform or soil type (Mattiske, 2016). Both taxa are expected to widely occur outside of the Premises.

## 8.5 Geology

### 8.5.1 Regional geology

The Premises is located within the Fitzroy Trough on the northern Canning Basin. The main geological units relevant to the Premises are the Broome Sandstone and the Mowanjum Sand.

### 8.5.2 Superficial units

The Mowanjum Sand occurs at the surface or beneath a veneer of other superficial units within the Premises, and consists of red-brown, fine-grained silty sand between 6 and 12 m thick and unsaturated (the red-brown sand is colloquially termed ‘Pindan’). The Mowanjum

[3] Grassland with an upper layer composed of eucalypts, and a dense middle layer composed of *Acacia* species.

Sand is a widespread sheet deposit of Quaternary age and unconformably overlies a weathered contact on the Broome Sandstone, and is overlain in placed by thin younger deposits.

The Broome Sandstone is overlain by superficial units comprising shoreline, aeolian and alluvial deposits – mainly the Mowanjum Sand, and is underlain by the Jarlemai Siltstone, of Late Jurassic to Early Cretaceous age. The upper part of 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. The lower part of the Broome Sandstone contains high grades of fine-grained heavy mineral sands, which at the Premises is relatively thick (35 – 55 m). The heavy mineral resource at the Premises is approximately 5 km long and 4 km wide, with the base of the mineralised sand body ranging from about 110 m AHD in the north to about 0 m AHD in the south.

## 8.6 Hydrogeology

### 8.6.1 Setting

The Broome aquifer is hosted in the Broome Sandstone and the saturated part of the overlying Emeriau Sandstone and Mowanjum Sand, which generally are 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 aquifer and acts as a major aquiclude between it and the Alexander Formation below (Rockwater, 2016).

### 8.6.2 Broome aquifer

The water table elevation over the Thunderbird deposit ranges from about 62 m AHD in the south to about 75 m AHD in the north at the edge of the deposit. The depth to groundwater is in excess of 20 m over most of the Premises.

A localised seasonal surface water ponding area located about 3 km south-east of the Premises exhibits water levels in the Broome aquifer of about 18 m below land surface and is therefore unlikely to be connected to the regional Broome aquifer[4].

### 8.6.3 Potential Groundwater Dependent Ecosystems

The following have been identified as being potential groundwater dependent ecosystems in proximity to the Premises:

- An intermittent soak located about 3 km south-east of the mine. Vegetation in this location has been described as paperbarks and *Eucalytpus tecifica* open woodland over sparse tussock grassland or sedgeland. Groundwater levels in the Broome aquifer are about 18 m below land surface in this region – this soak is therefore more likely related to localised seasonal surface water ponding;
- River valleys associated with the Fraser River South, about 8 km south-east of the mine and with depths to groundwater ranging from less than 5 m to more than 20 m; and
- Jarlemai Siltstone ‘soaks’. The Fraser River North has developed over the Jarlemai Siltstone to the north-east of the mine.

[4] Monitoring bores are proposed to further assess this region.

## 8.7 Surface hydrology

The distances to groundwater and water sources are shown in Table 15.

**Table 15: Groundwater and water sources**

| Groundwater and water sources | Distance from the Premises |
|---|---|
| Public drinking water source areas | The nearest Public Drinking Water reserves are near Broome and Derby, approximately 50 km and 75 km, respectively, from the Premises |
| Surface water catchments | The Premises is within the Fraser River catchment. The Logue and Little Logue River catchments are crossed by the site access road and do not contain any other project infrastructure<br>There are no declared surface water areas within M04/459 or the Logue and Fraser River catchments |
| Major watercourses and waterbodies | The Fraser River is located approximately 7 km north of the Premises, with tributaries that extend down to the north of the Premises |
| | The headwaters of Fraser River South is located approximately 4 km south of the Premises |

## 8.8 Determination of emission, pathway and receptor

In undertaking its risk assessment, DWER will identify all potential emissions pathways and potential receptors to establish whether there is a Risk Event which requires detailed risk assessment.

To establish a Risk Event there must be an emission, a receptor which may be exposed to that emission through an identified actual or likely pathway, and a potential adverse effect to the receptor from exposure to that emission. Where there is no actual or likely pathway and/or no receptor, the emission will be screened out and will not be considered as a Risk Event. In addition, where an emission has an actual or likely pathway and a receptor which may be adversely impacted, but that emission is regulated through other mechanisms such as Part IV of the EP Act, that emission will not be risk assessed further and will be screened out through Tables 16 & 17.

The identification of the sources, pathways and receptors to determine Risk Events are set out in Tables 16 & 17 below.

**Table 16. Identification of emissions, pathway and receptors during construction**

| Risk Events | | | | | | Continue to detailed risk assessment | Reasoning |
|---|---|---|---|---|---|---|---|
| **Sources/Activities** | | **Potential emissions** | **Potential receptors** | **Potential pathway** | **Potential adverse impacts** | | |
| ***Construction of mining infrastructure for ore processing, sewage treatment plant and landfill trenches*** | Civil excavation/ earthworks/ vehicle movements on unsealed roads<br>Construction of ore processing facilities, wastewater treatment plant and landfill trenches<br>Clearing of native vegetation, topsoil stripping and O/B removal<br>Pre-production mining and stockpiling | Noise | Fauna and flora in close proximity<br>Mt Jowlaenga Station (8 km)[1]<br>Nillibubbica rest stop (27 km)<br>Kimberley Meat Co. (28 km)<br>Bidan Aboriginal Community (28 km)<br>Yeeda Outstation (28 km) | Air / wind dispersion | Amenity impacts/ health impacts | No | The risk of health/amenity impacts from noise and dust generated during pre-mining and production works is considered to be Low, based on separation to sensitive receptors (+27 km). |
| | | Fugitive emissions (dust) | | | | No | |
| | | Oxidation of Acid Sulfate Soils from physical disturbance of ASS material | Groundwater, groundwater dependent vegetation | Leaching from in situ ASS material | Groundwater contamination (acidification) | No | The risk of disturbing ASS from excavations above the natural water table (approximately 83.5 m below ground level) is Low, as pre-mining and production works will not extend below the natural water table. |
| | Commissioning of the sewage treatment plant | Untreated/treated sewage (nutrient-rich effluent) discharge to land | Groundwater<br>Soil and native vegetation associated with drainage lines in proximity to the sewage treatment plant | Direct discharge | Groundwater contamination | No | The risk of contaminating groundwater from controlled/uncontrolled discharges of effluent is considered to be Low, based on separation to the natural water table (approximately 83.5 m below ground level). |
| | | | | | Soil contamination, inhibiting vegetation growth and survival | No | The risk of contaminating soil from controlled/uncontrolled discharges of effluent is considered to be Low, based on implementation of controls proposed by the Applicant, i.e. only discharging treated wastewater that meets specified criterion. |
| | | Odour | Human receptors (as listed above) | Air / wind dispersion | Amenity impacts | No | The risk of odour impacting on the amenity of human receptors during commissioning of the WWTP is considered to be Low, based on separation to sensitive receptors (+27 km). |

Note 1: Currently abandoned, but may become a receptor if inhabited in the future.

**Table 17: Identification of emissions, pathway and receptors during operation**

| Risk Events | | | | | | Continue to detailed risk assessment | Reasoning |
|---|---|---|---|---|---|---|---|
| **Sources/Activities** | | **Potential emissions** | **Potential receptors** | **Potential pathway** | **Potential adverse impacts** | | |
| ***Category 8: Mineral sands mining or processing: premises on which mineral sands ore is mined, screened, separated or otherwise processed*** | ***PRE-MINING WORKS*** | | | | | | |
| | Clearing of native vegetation, topsoil stripping and O/B removal | Noise | Fauna and flora in close proximity, etc. (see above) | Air / wind dispersion | Amenity impacts/ health impacts | No | The risk of health/amenity impacts from noise and dust generated during pre-mining works is considered to be Low for the reasons stated above. |
| | | Fugitive emissions (dust) | | | | No | |
| | | Oxidation of Acid Sulfate Soils | Groundwater, groundwater dependent vegetation | Leaching from in situ ASS material | Groundwater contamination (acidification) | No | The risk of disturbing ASS during surface pre-mining works is considered to be Low for the reasons stated above. |
| | ***MINING & PRIMARY PROCESSING*** | | | | | | |
| | Mining and processing of ore<br>Includes emissions during commissioning of ore processing facilities | Noise | Fauna and flora in close proximity, etc. (see above) | Air / wind dispersion | Amenity impacts/ health impacts | No | The risk of health/amenity impacts from noise and dust generated during mining and processing of ore is considered to be Low for the reasons stated above. |
| | | Fugitive emissions (dust) | | | | | |
| | | | | | Soil contamination, suppression of photosynthetic and respiratory functions of native vegetation, including several Priority flora species within the Premises boundary and immediate surrounds | No | The risk of impacts to native vegetation from dust loading during mining and processing of ore is considered to be Low based on the mining method proposed (in-pit) and dust control methods to be employed during active mining.<br>Any dust impacts that may occur can be regulated under the provisions of Section 49 of the EP Act. |

| Risk Events | | | | | | Continue to detailed risk assessment | Reasoning |
|---|---|---|---|---|---|---|---|
| Sources/Activities | | Potential emissions | Potential receptors | Potential pathway | Potential adverse impacts | | |
| | | Oxidation of Acid Sulfate Soils | Groundwater, groundwater dependent vegetation | Leaching from in-situ material | Groundwater contamination (acidification) | No | The risk of disturbing ASS during the first few decades of mining is considered to be Low for the reasons stated above.<br>***This aspect will require reviewing prior to mining below the water table (approximately Year 15).*** |
| | | Contaminated surface water runoff | Native vegetation associated with drainage lines associated surface water or shallow groundwater | Direct discharge | Contamination of drainage lines, inhibiting vegetation growth and survival | No | The risk of contaminated surface water runoff causing off-site impacts is considered to be Low, based on the sandy soils with low average annual runoff coefficients (0.00 – 0.07) and implementation of surface water control measures proposed by the Applicant. |
| | | | | | Erosion and sedimentation | | |
| | De-slimed ore stockpile<br>HMC stockpile | Seepage of water entrained within the de-slimed ore/HMC to groundwater | Groundwater, groundwater dependent vegetation | Vertical seepage through base of stockpile | Groundwater contamination | No | The risk of contamination/mounding from seepage to groundwater from the HMC stockpile is considered to be Low, based on the depth to groundwater (+20 m) and implementation of seepage control measures (sub-surface drainage) proposed by the Applicant. |
| | | | | | Groundwater mounding | No | |
| | | Contaminated surface water runoff | Native vegetation associated with drainage lines in proximity to the stockpile | Direct discharge | Contamination of drainage lines, inhibiting vegetation growth and survival | No | The risk of runoff from stockpiles causing off-site impacts is considered to be Low for the reasons stated above. |
| | | | | | Erosion and sedimentation | | |
| | | Dust lift-off | Fauna and flora in close proximity, etc. (see above)<br>Native vegetation, including several Priority flora species within the Premises boundary and immediate surrounds | Air / wind dispersion | Amenity impacts/ health impacts | No | The risk of health/amenity impacts from dust generated from ore/HMC stockpiles is considered to be Low for the reasons stated above. |
| | | | | | Soil contamination, suppression of photosynthetic and respiratory functions | No | Dust loading impacts to native vegetation from ore/HMC stockpiles is unlikely, given the distance from stockpiles (in the middle of the processing plant area) to nearby native vegetation. |
| | Disposal of mine tailings (to initial TSF) | Seepage of water entrained within tailings to groundwater | Groundwater, groundwater dependent vegetation in proximity to TSF | Lateral or vertical seepage through base of TSF | Groundwater contamination | Yes | To be assessed under Stage 1B application. |
| | | | | | Groundwater mounding | | |
| | | Rupture of pipeline causing tailings discharge to land | Native vegetation associated with drainage lines associated surface water or shallow groundwater | Direct discharge | Contamination of drainage lines, inhibiting vegetation growth and survival | | |
| | | | | | Erosion and sedimentation | | |
| | Disposal of mine tailings (to mine void)<br>Includes:<br>- WCP sand rejects<br>- WCP clay slimes<br>- Combined CUP and MSP tailings<br>- MSP rejects<br>- Gypsum (acid neutralisation residue from HAL circuit) | Seepage of water entrained within the tailings to groundwater | Groundwater, groundwater dependent vegetation in proximity to mine void | Lateral or vertical seepage through base of mine void | Groundwater contamination | | |
| | | | | | Groundwater mounding | | |
| | | Rupture of pipeline causing tailings discharge to land or waters | Native vegetation associated with drainage lines in proximity to pipeline alignment | Direct discharge | Contamination of drainage lines, inhibiting vegetation growth and survival | | |
| | | | | | Erosion and sedimentation | | |
| | | Overtopping/breach of containment causing discharge to land | Native vegetation associated with drainage lines associated surface water or shallow groundwater | | Contamination of drainage lines, inhibiting vegetation growth and survival | | |
| | | | | | Erosion and sedimentation | | |
| | Return water pipelines | Rupture of pipeline causing return water discharge to land | Native vegetation associated with drainage lines in proximity to pipeline alignment | | Contamination of drainage lines, inhibiting vegetation growth and survival | | |
| | | | | | Erosion and sedimentation | | |

| Risk Events | | | | | | Continue to detailed risk assessment | Reasoning |
|---|---|---|---|---|---|---|---|
| Sources/Activities | | Potential emissions | Potential receptors | Potential pathway | Potential adverse impacts | | |
| | ***SECONDARY PROCESSING*** | | | | | | |
| | Fluid bed dryers (gas-fired) | Air emissions – particulates | Fauna and flora in close proximity, etc. (see above) | Air / wind dispersion | Amenity impacts/ health impacts<br>Impacts to existing ambient air quality and local airshed | No | The risk of impacts to existing ambient air quality from particulates (fluid bed dryer off-gas) is considered to be Low, based on separation to human receptors and implementation of pollution control measures (bag filters) proposed by the Applicant. Expected PM stack emissions are less than 50 mg/m$^3$ from 30 m high stacks. |
| | Reheaters (gas-fired) | | | | | No | The risk of impacts to existing ambient air quality from particulates (reheater off-gas) is considered to be Low, based on separation to human receptors and expected PM stack emissions of less than 50 mg/m$^3$ from 30 m high stacks. |
| | Hot Acid Leach reactor (HAL) | Air emissions – acidic fumes | | | | No | The risk of impacts to existing ambient air quality from acidic fumes (HAL off-gas) is considered to be Low, based on separation to human receptors and the implementation of pollution control measures (wet spray scrubber) proposed by the Applicant. |
| | Low Temperature Roaster (LTR) | Air emissions – particulates | Fauna and flora in close proximity, etc. (see above) | Air / wind dispersion | Amenity impacts/ health impacts<br>Impacts to existing ambient air quality and local airshed | No | The risk of impacts to existing ambient air quality from particulates (LTR pre-heating off-gas) is considered to be Low, based on separation to human receptors and implementation of pollution control measures (venturi scrubber) proposed by the Applicant. Expected PM stack emissions are less than 75 mg/m$^3$ from 60 m high stacks. |
| ***Other (related to Cat 8 activities)*** | Acid neutralisation plant | Spills/leaks of sulfuric acid and caustic soda | Groundwater<br>Soil and native vegetation associated with drainage lines in proximity to the handling plants | Direct discharge | Soil contamination, inhibiting vegetation growth and survival | No | The risk of impacts from spills or leaks of hazardous materials is considered to be Low, based on separation to the natural water table (approximately 83.5 m below ground level) and implementation of pollution control measures (bunding, collection sumps) proposed by the Applicant.<br>Additionally, the risks associated with the storage and handling of dangerous goods are regulated by DMIRS under the *Dangerous Goods Safety Act 2004*, *Dangerous Goods Safety (Storage and Handling of Non-explosives) Regulations 2007*, and the Code of Practice for the Storage and Handling of Dangerous Goods. |
| | Sulfuric acid storage and handling plant | Spills/leaks of sulfuric acid | | | | No | |
| | Caustic soda storage and handling plant | Spills/leaks of caustic | | | | No | |
| | Lime storage and handling plant | Spills/leaks of lime | | | | No | |
| | Dewatering | Groundwater drawdown | Groundwater dependent vegetation | N/A | Impacts on groundwater dependent vegetation<br>Groundwater contamination (acidification) | No | Potential impacts from groundwater drawdown are regulated by DWER under the RIWI Act. |
| | Naturally Occurring Radioactive Material (NORM) | Seepage to groundwater from tailings | Groundwater, groundwater dependent vegetation | Lateral or vertical seepage through base of mine void | Groundwater contamination | No | Radiological risks are regulated by DMIRS/RCWA under the *Radiation Safety Act 1975*. |
| ***Category 54: Sewage facility: premises on which sewage is treated or from which treated sewage is discharged onto land or into waters*** | Infrastructure and influent pipework | Overtopping/ overflow/ rupture or failure of pipework | Soil and native vegetation associated with drainage lines in proximity to the sewage treatment plant | Direct discharge | Soil contamination, inhibiting vegetation growth and survival | No | The risk of contaminating soil from controlled/uncontrolled discharges of effluent is considered to be Low, based on implementation of controls proposed by the Applicant, i.e. only discharging treated wastewater that meets specified criterion. |
| | Discharge of treated sewage – applied to native vegetation using reticulated sprinklers | Treated sewage (nutrient-rich effluent) discharge to land | | | | No | |
| | | Odour | Human receptors (as listed above) | Air / wind dispersion | Amenity impacts | No | The risk of odour impacting on the amenity of human receptors is considered to be Low, based on separation to sensitive receptors. |
| | Treated sewage pipeline to irrigation spray field | Rupture of pipeline causing treated sewage discharge to land | Native vegetation associated with drainage lines in proximity to pipeline alignment | Direct discharge | Soil contamination, inhibiting vegetation growth and survival | No | The risk of soil contamination from uncontrolled discharges of treated sewage is considered to be Low for the reasons stated above. |
| ***Category 89: Putrescible landfill*** | Landfill trenches | Seepage of leachate to groundwater | Groundwater, groundwater dependent vegetation | Lateral or vertical seepage through base of trenches | Groundwater contamination | No | The risk of contamination from seepage to groundwater from the landfill trenches is considered to be Low, based on the depth to groundwater (+20 m). |

## 8.9 Consequence and Likelihood of Risk Events

A risk rating will be determined for risk events in accordance with the Risk Rating Matrix set out in Table 18 below.

**Table 18: Risk Rating Matrix**

| Likelihood | Consequence | | | | |
|---|---|---|---|---|---|
| | Slight | Minor | Moderate | Major | Severe |
| Almost Certain | Medium | High | High | Extreme | Extreme |
| Likely | Medium | Medium | High | High | Extreme |
| Possible | Low | Medium | Medium | High | Extreme |
| Unlikely | Low | Medium | Medium | Medium | High |
| Rare | Low | Low | Medium | Medium | High |

DWER will undertake an assessment of the consequence and likelihood of the Risk Event in accordance with Table 19 below.

**Table 19: Risk Criteria Table**

| **Likelihood** | | **Consequence** | | |
|---|---|---|---|---|
| **The following criteria has been used to determine the likelihood of the Risk Event occurring.** | | **The following criteria has been used to determine the consequences of a Risk Event occurring:** | | |
| | | | **Environment** | **Public health* and amenity (such as air and water quality, noise, and odour)** |
| Almost Certain | The risk event is expected to occur in most circumstances | Severe | • **onsite impacts**: catastrophic<br>• **offsite impacts local scale**: high level or above<br>• **offsite impacts wider scale:** mid-level or above<br>• Mid to long-term or permanent impact to an area of high conservation value or special significance^<br>• Specific Consequence Criteria (for environment) are significantly exceeded | • Loss of life<br>• **Adverse health effects:** high level or ongoing medical treatment<br>• Specific Consequence Criteria (for public health) are significantly exceeded<br>• **Local scale impacts:** permanent loss of amenity |
| Likely | The risk event will probably occur in most circumstances | Major | • **onsite impacts**: high level<br>• **offsite impacts local scale**: mid-level<br>• **offsite impacts wider scale**: low level<br>• Short-term impact to an area of high conservation value or special significance^<br>• Specific Consequence Criteria (for environment) are exceeded | • **Adverse health effects:** mid-level or frequent medical treatment<br>• Specific Consequence Criteria (for public health) are exceeded<br>• **Local scale impacts**: high level impact to amenity |
| Possible | The risk event could occur at some time | Moderate | • **onsite impacts**: mid-level<br>• **offsite impacts local scale**: low level<br>• **offsite impacts wider scale**: minimal<br>• Specific Consequence Criteria (for environment) are at risk of not being met | • **Adverse health effects:** low level or occasional medical treatment<br>• Specific Consequence Criteria (for public health) are at risk of not being met<br>• **Local scale impacts:** mid-level impact to amenity |
| Unlikely | The risk event will probably not occur in most circumstances | Minor | • **onsite impacts**: low level<br>• **offsite impacts local scale**: minimal<br>• **offsite impacts wider scale**: not detectable<br>• Specific Consequence Criteria (for environment) likely to be met | • Specific Consequence Criteria (for public health) are likely to be met<br>• **Local scale impacts:** low level impact to amenity |
| Rare | The risk event may only occur in exceptional circumstances | Slight | • **onsite impact**: minimal<br>• Specific Consequence Criteria (for environment) met | • **Local scale**: minimal to amenity<br>• Specific Consequence Criteria (for public health) met |

^ Determination of areas of high conservation value or special significance should be informed by the *Guidance Statement: Environmental Siting.*

* In applying public health criteria, DWER may have regard to the Department of Health's, *Health Risk Assessment (Scoping) Guidelines* **"on-site"** means within the prescribed premises boundary.

## 8.10 Acceptability and Treatment of Risk Event

DWER will determine the acceptability and treatment of Risk Events in accordance with the Risk Treatment Table 20 below:

**Table 20: Risk Treatment Table**

| Rating of Risk Event | Acceptability | Treatment |
|---|---|---|
| Extreme | Unacceptable. | Risk Event will not be tolerated. DWER may refuse application. |
| High | May be acceptable.<br>Subject to multiple regulatory controls. | Risk Event may be tolerated and may be subject to multiple regulatory controls. This may include both outcome-based and management conditions. |
| Medium | Acceptable, generally subject to regulatory controls. | Risk Event is tolerable and is likely to be subject to some regulatory controls. A preference for outcome-based conditions where practical and appropriate will be applied. |
| Low | Acceptable, generally not controlled | Risk Event is acceptable and will generally not be subject to regulatory controls. |

## 8.11 Risk Assessment

The Delegated Officer has assessed potential emissions pathways and receptors for all possible Risk Events (Tables 16 & 17), and considers potential impacts will be limited by the remote location of the proposed works and the absence of nearby sensitive receptors.

The Delegated Officer therefore considers the risks associated with the Stage 1A works to be Low, and that minor emissions such as fugitive dust and contaminated surface water runoff can be regulated by the general provisions of the EP Act.

# 9. Regulatory controls

DWER will determine regulatory controls having regard to the adequacy of controls proposed by the Applicant. The conditions of the Works Approval and Licence will be set to give effect to the determined regulatory controls.

## 9.1 Works Approval controls

### 9.1.1 Infrastructure and equipment

The infrastructure and equipment authorised for construction have been specified in Table 2 of the Works Approval.

***Note:*** *The requirements specified in Table 2 of the Works Approval are required where a potential risk identified in this Decision Report has been determined to be low based on implementation of Applicant control measures.*

***Grounds:*** *The design and construction requirements of the process plant and associated mine infrastructure are required to be constructed in accordance with the relevant engineering drawings as submitted with the Application, in order to minimise the risk of impacts from upset operating conditions.*

### 9.1.2 Emissions from commissioning works

A control has been imposed (Condition 5) to specify the nominated location as the authorised disposal area for treated sewage during commissioning works.

***Grounds:*** *DWER's risk assessment is based on the disposal of treated sewage in the*

*locations specified in the Application. Disposal of treated sewage in locations other than those specified has not been risk assessed, and the defence provisions of s.74, 74A and 74B would therefore not apply.*

### 9.1.3 Record keeping

A number of conditions have been applied to the Works Approval (Conditions 6 and 7) to prescribe the minimum record keeping requirements. They relate to the standards for book-keeping and the requirement to produce records to the CEO upon request.

***Grounds:*** *The requirements specified above are necessary to demonstrate compliance with other requirements of the Works Approval.*

## 9.2 Licence controls

Licence L9077/2017/1 will be issued shortly in relation to the preliminary works on the Premises (W6072/2017/1). This Licence will require an amendment following the completion of Stage 1A, Phase 2 works to include controls for operation of the sewage treatment plant, landfill and early stage mining activities.

The Licence will require further amendment following the completion of Stage 1A, Phase 3/4 works, to include controls for operation of the process plant and associated infrastructure. It is also expected that controls will be imposed through the Licence with respect to tailings disposal, which will be assessed under a separate works approval for 'Stage 1B'.

# 10. Applicant's comments

The Applicant was provided with the draft Decision Report and draft issued Works Approval on 14 August 2018. [summarise comments]

# 11. Conclusion

This assessment of the risks of activities on the Premises has been undertaken with due consideration of a number of factors, including the documents and policies specified in this Decision Report (summarised in Appendix 1).

Based on this assessment, it has been determined that the Issued Works Approval will be granted subject to conditions commensurate with the determined controls and necessary for administration and reporting requirements.

**Tim Gentle**
**Manager – Resource Industries**

Delegated Officer
under section 20 of the *Environmental Protection Act 1986*

# Appendix 1: Key documents

| | Document title | In text ref | Availability |
|---|---|---|---|
| 1. | Thunderbird Mineral Sands Project – Minor or Preliminary Works – M04/459 and L04/85 – Works Approval and Licence Application. | Application | DWER records (A1449925) |
| 2. | DER, July 2015. *Guidance Statement: Regulatory principles.* Department of Environment Regulation, Perth. | DER, 2015a | accessed at www.dwer.wa.gov.au |
| 3. | DER, October 2015. *Guidance Statement: Setting Conditions.* Department of Environment Regulation, Perth. | DER, 2015b | |
| 4. | DER, November 2016. *Guidance Statement: Environmental Siting*. Department of Environment Regulation, Perth. | DER, 2016 | |
| 5. | DER, February 2017. *Guidance Statement: Risk Assessments*. Department of Environment Regulation, Perth. | DER, 2017a | |
| 6. | DER, February 2017. *Guidance Statement: Decision Making*. Department of Environment Regulation, Perth. | DER, 2017b | |
| 7. | DMP, October 2015. *Mining Act Guidelines – Basic Provisions*. Department of Mines and Petroleum, Perth. | DMP, 2015 | accessed at www.dmp.wa.gov.au |
| 8. | DoW, December 2010. *Kimberley Regional Water Plan 2010 – 2030*. Department of Water, Perth. | DoW, 2010 | accessed at www.water.wa.gov.au |
| 9. | Referral Decision – Thunderbird Mineral Sands Project, minor and preliminary works, WA (EPBC 2017/7968). Department of the Environment and Energy. | EPBC 2017/7968 | accessed at www.epbcnotices.environment.gov.au |

## Appendix 2: Summary of applicant's comments on risk assessment and draft conditions

| Condition | Summary of Applicant comment | DWER response |
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# Attachment 1: Issued Works Approval W6088