3. PROJECT DESCRIPTION

3.1 KEY CHARACTERISTICS

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

Table 6: Key Characteristics of the Project

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

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

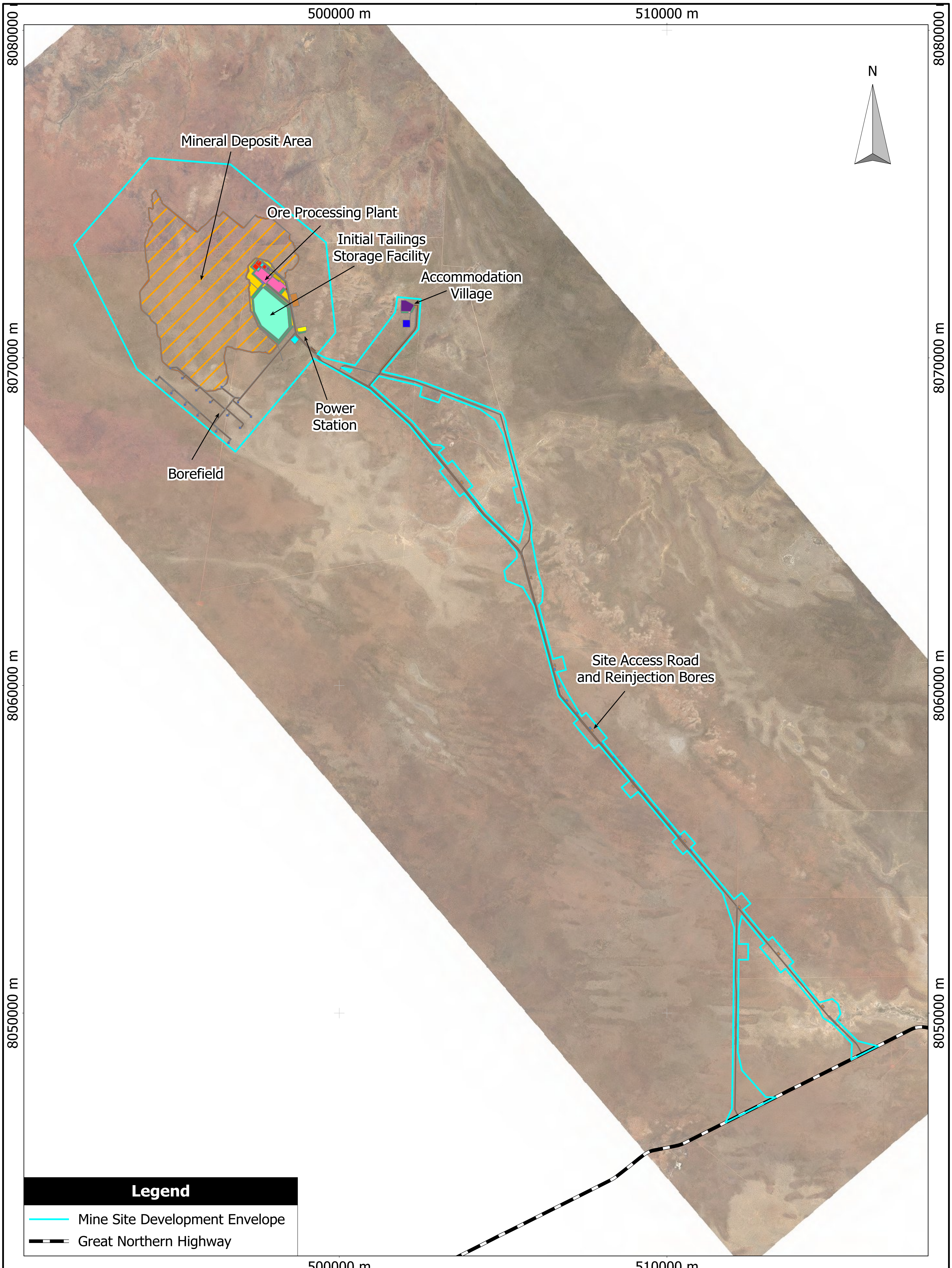

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Figure 4

Mine Site Development Envelope Infrastructure Layout

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3.2 TIMING AND STAGING OF PROJECT

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

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

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

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

3.3 MINING OPERATIONS

3.3.1 Mining Method

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

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

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

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

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

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

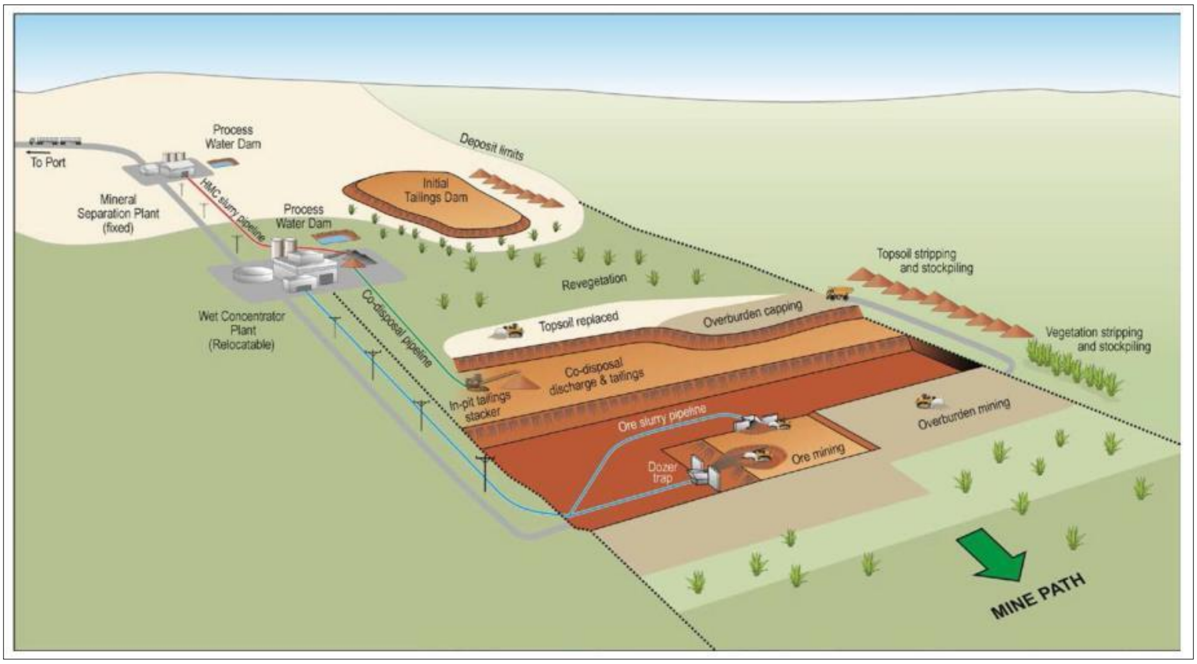

Figure 5: Conceptual Mining Method Schematic

3.3.2 Mine Design

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

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

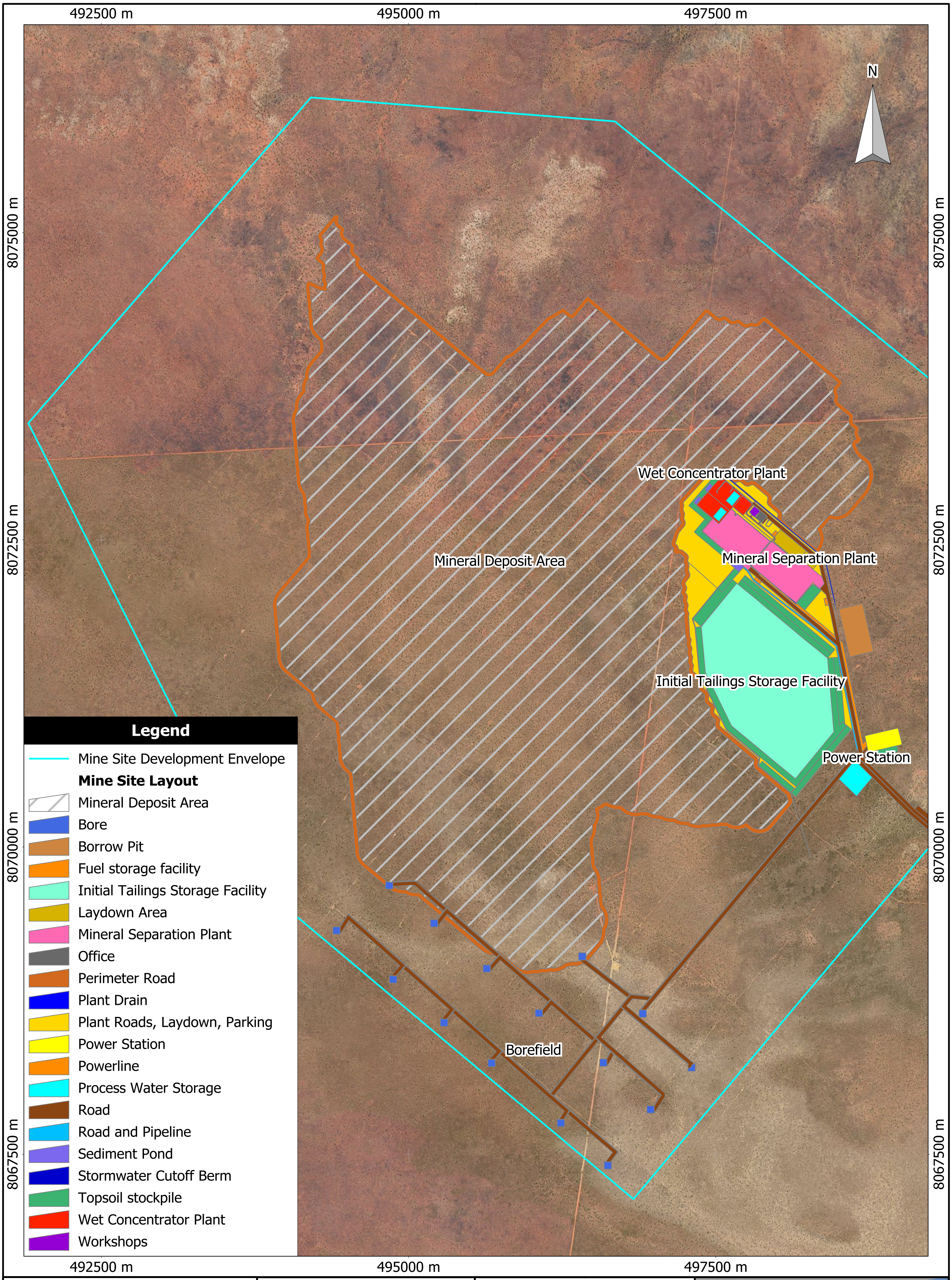

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Figure 6

Proposed Life of Mine Mineral Deposit Footprint and Layout

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

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

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

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

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

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

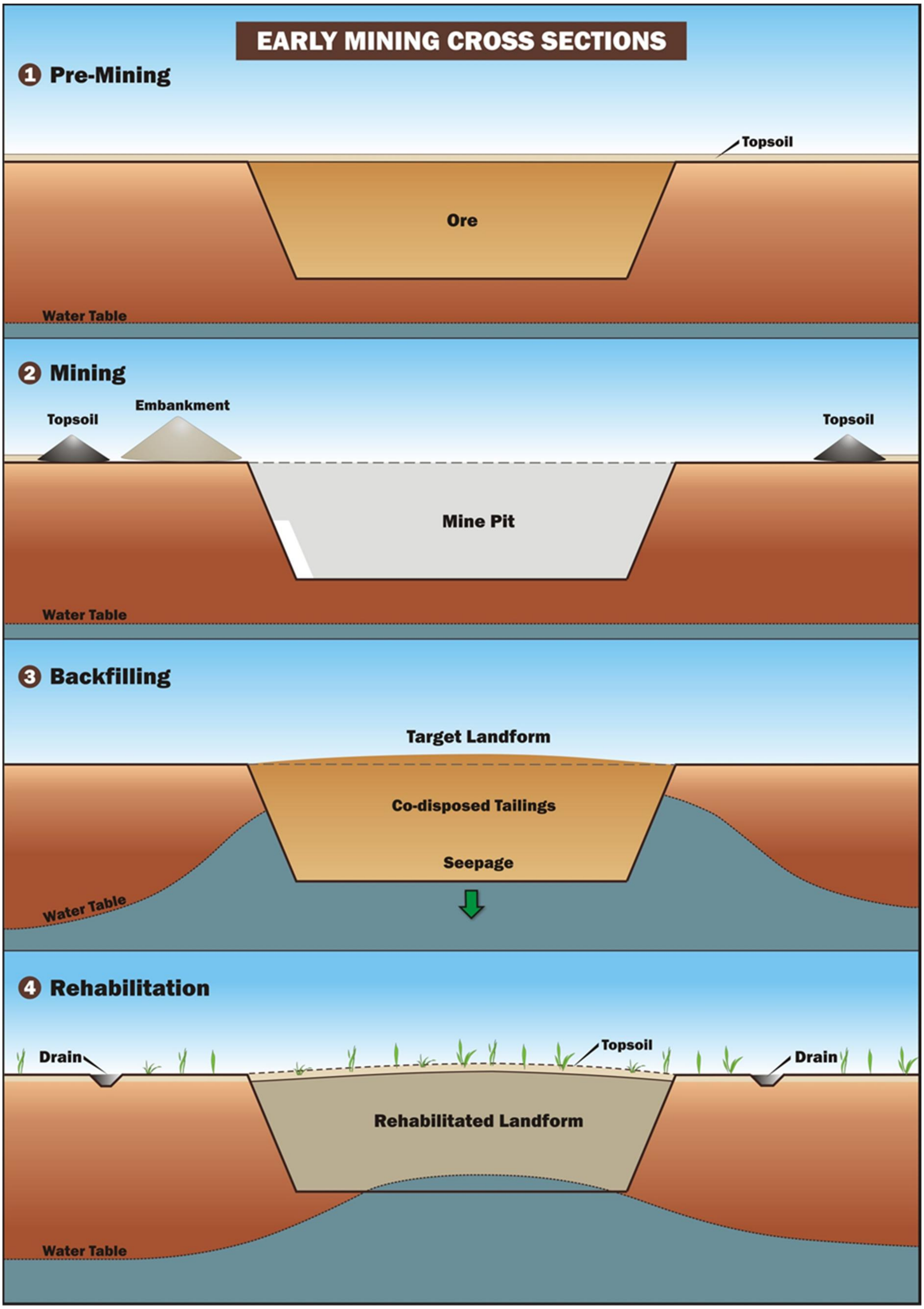

Figure 7: Mine Cross Section – Mining Above Water Table

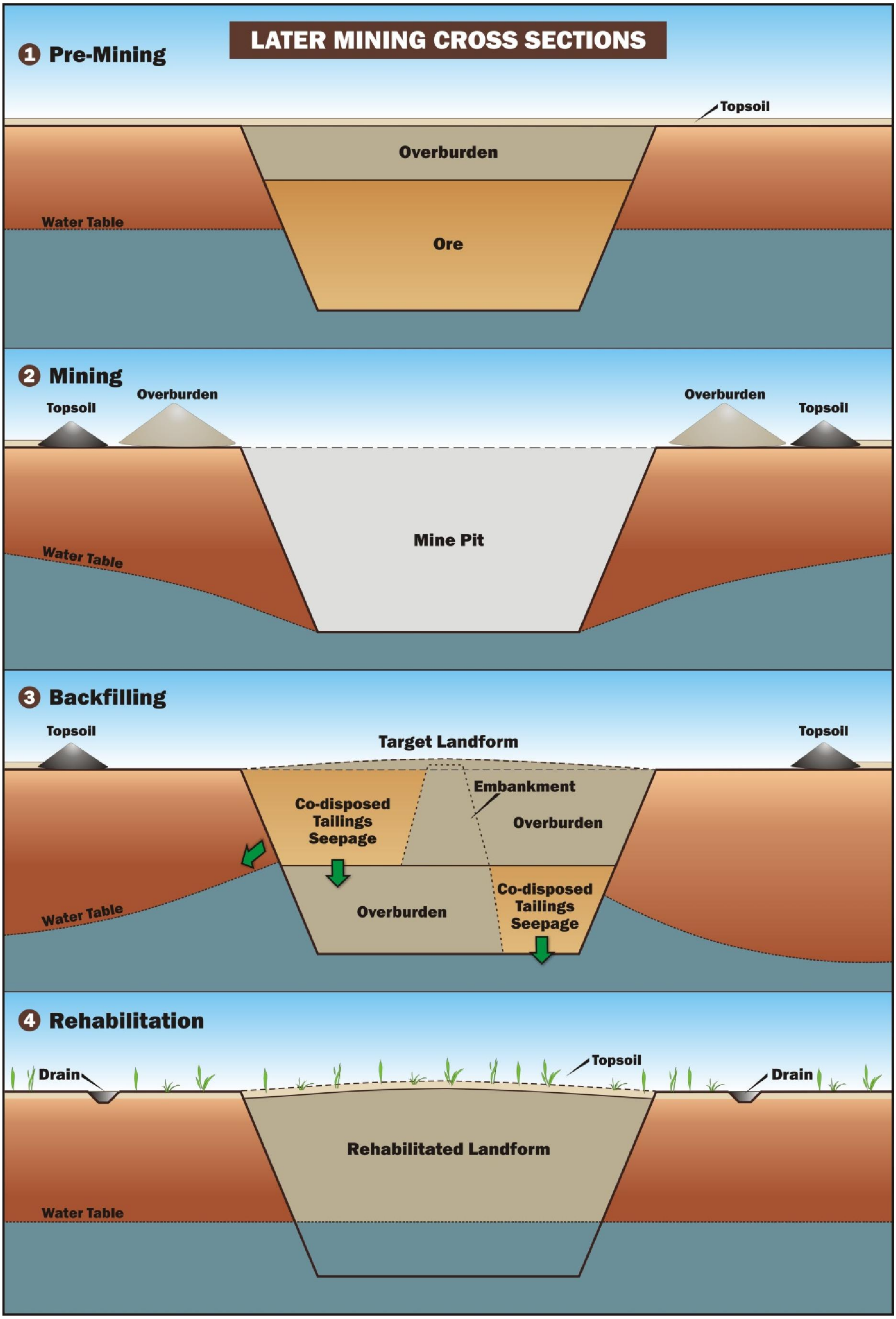

Figure 8: Mine Cross Section – Mining Below Water Table

3.3.3 Mine Schedule

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

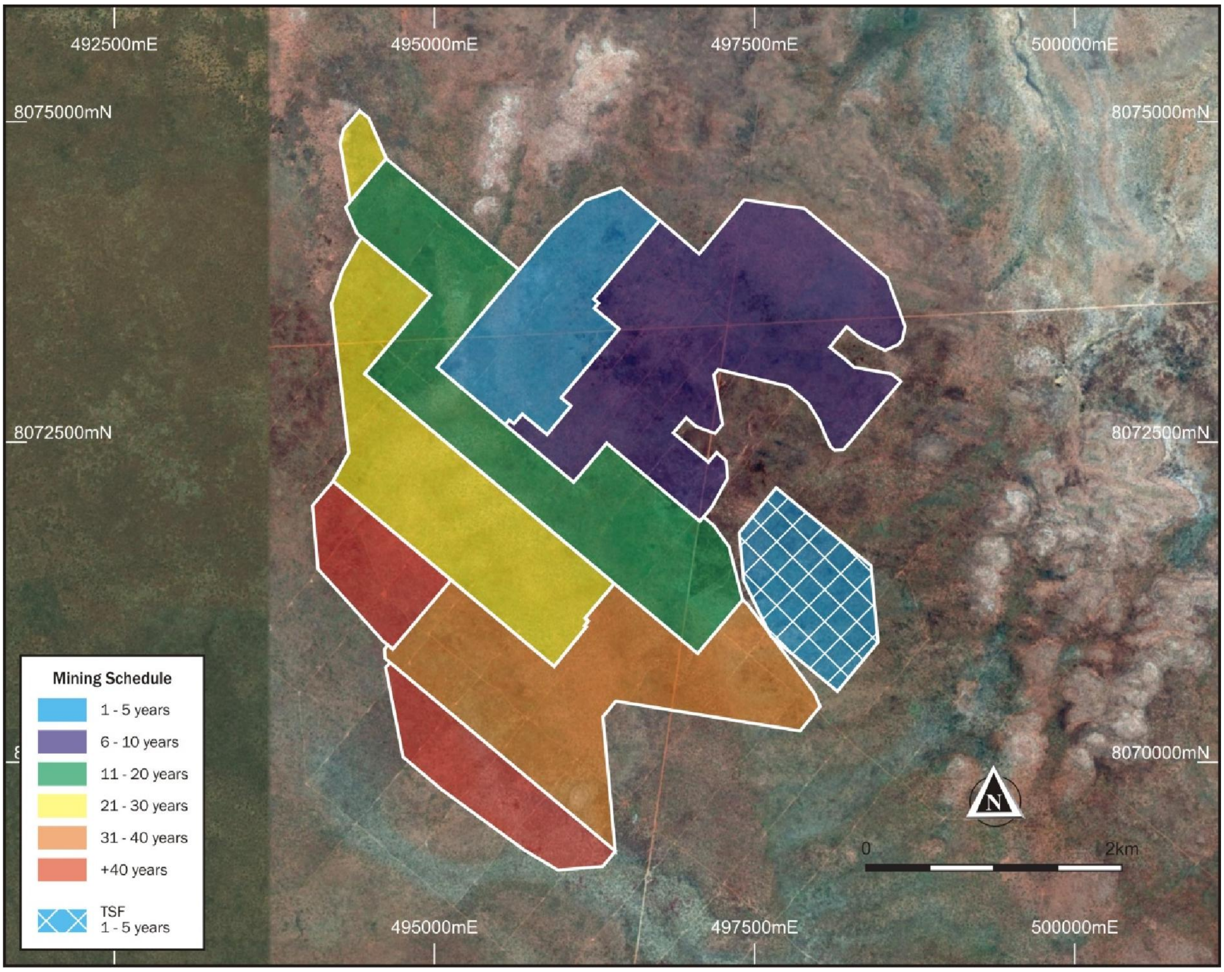

Figure 9: Proposed Mining Schedule

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

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

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

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

3.3.4 Mine Dewatering

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

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

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

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

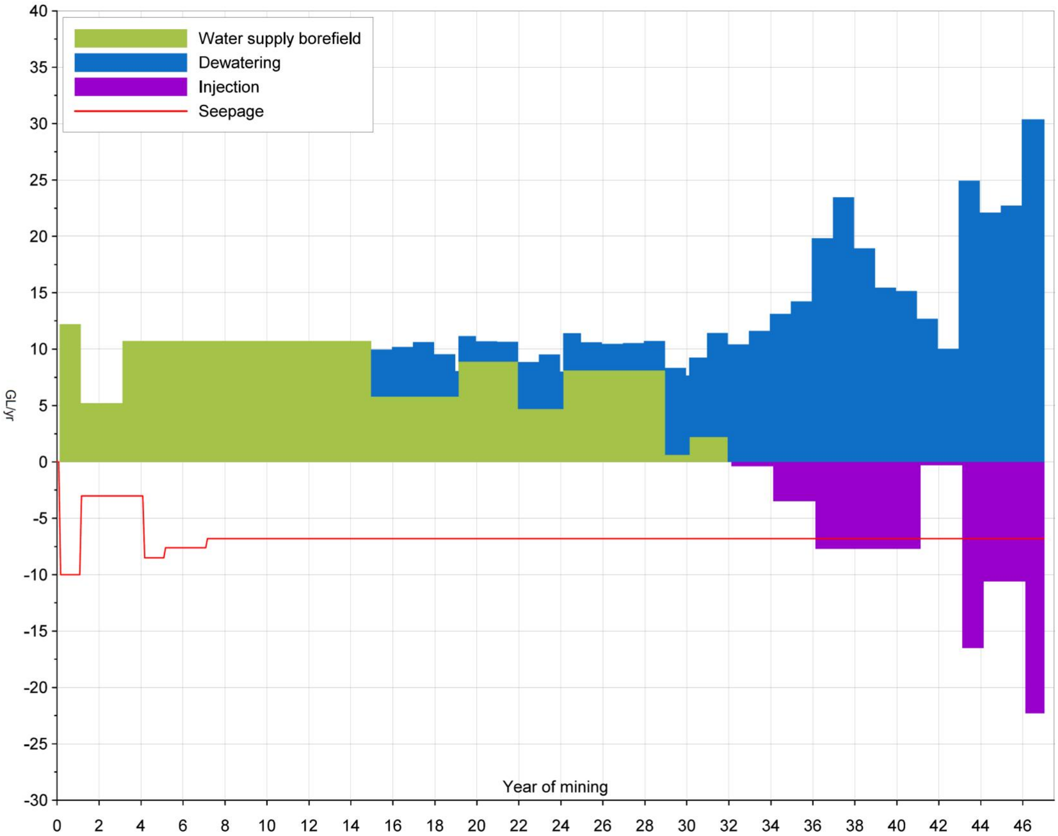

Figure 10: Predicted Life of Mine Water Management Volumes

3.4 ORE PROCESSING

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

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

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

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

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

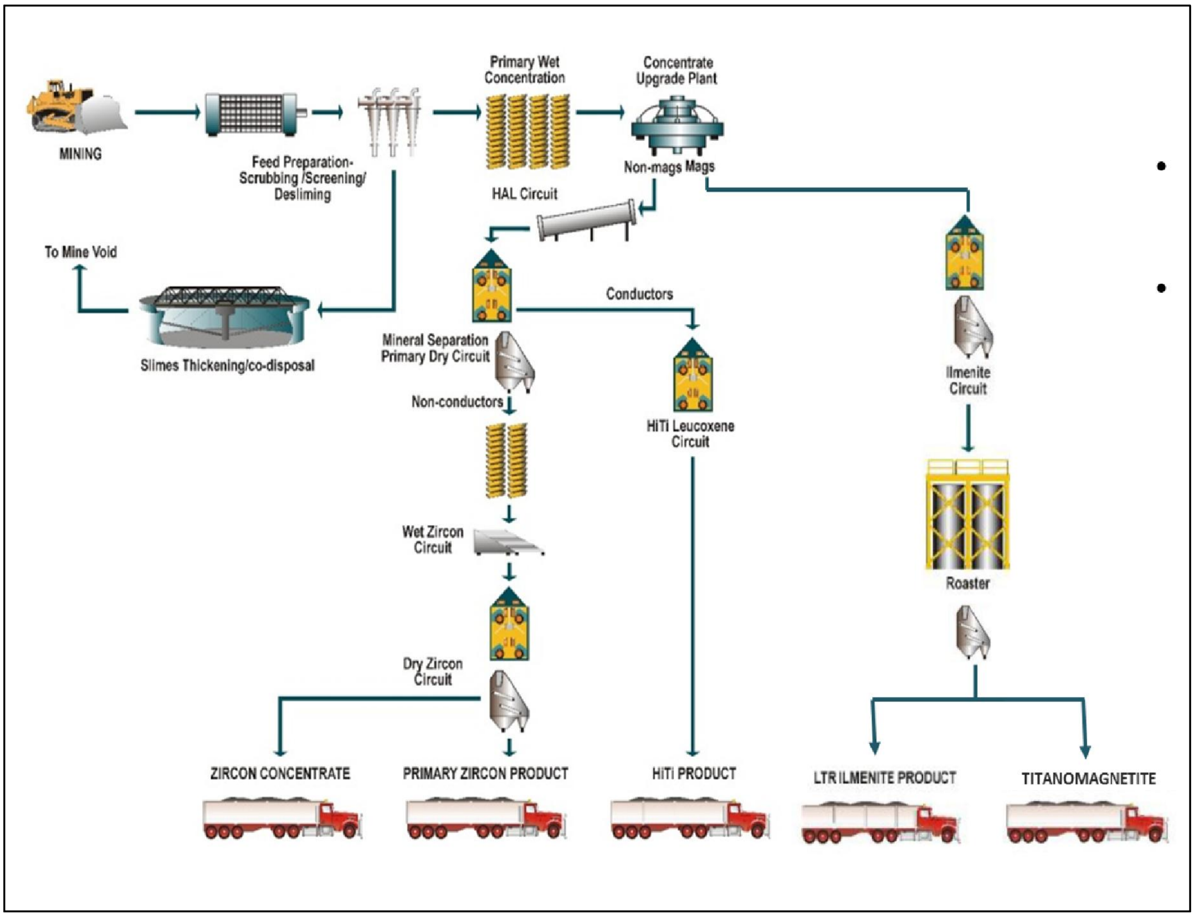

Figure 11: Ore Processing Process Flow Sheet

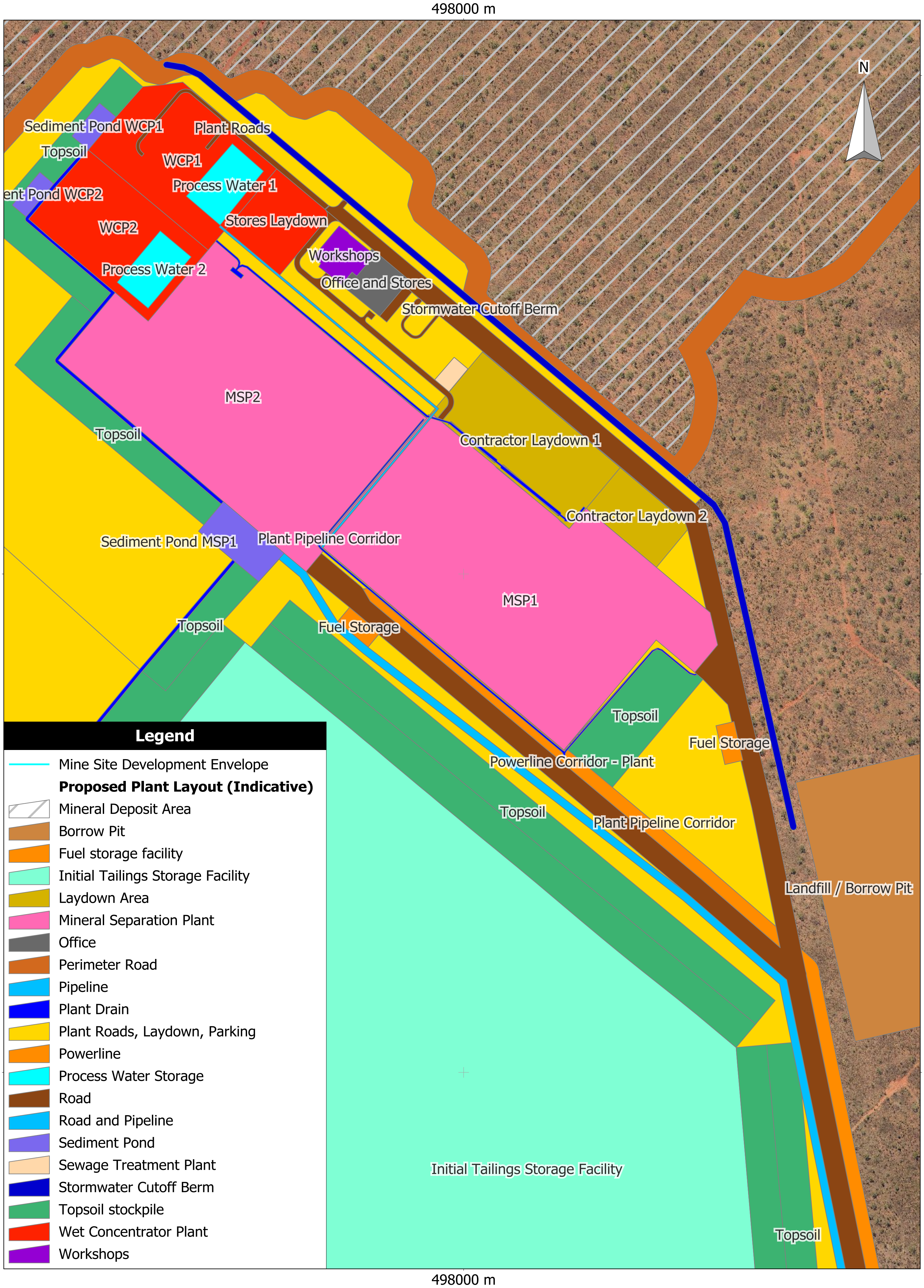

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Figure 12

Ore Processing Plant Layout

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W:\Sheffield Resources\PER\Drawings\PER Map.map 11/11/2016 F12 Ore Processing Plant Layout A4P

3.4.1 Process Waste Types and Volumes

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

Table 8: Process Waste Types and Proportions

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

3.4.2 Process Waste Disposal Methods

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

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

3.4.2.1 Tailings Storage Facility

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

3.4.2.2 Co-disposal within Mining Area

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

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

3.5 WATER

3.5.1 Water Sources

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

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

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

Table 9: Project Water Supply

Input		Quantity (GL/yr)		
		Stage 1 (Year 1 – 3)	Stage 2 (Year 4 – 15)	Stage 3 (Year 15+)
Water Abstracted	Mine dewatering	0	0	10.7 – 32.7
	Borefield abstraction	5.2 – 12.2	10.7	
	Total	**5.2 – 12.2**	**10.7**	**10.7 – 32.7**
Water Returned	Aquifer reinjection	0	0	0 - 22
	Modelled seepage	3.0 - 10.0	6.8 - 8.5	6.8

3.5.2 Water Usage

3.5.2.1 Construction

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

3.5.2.2 Operations

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

Table 10: Project Operation Water Requirements

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

3.5.2.3 Groundwater Reinjection

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

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

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

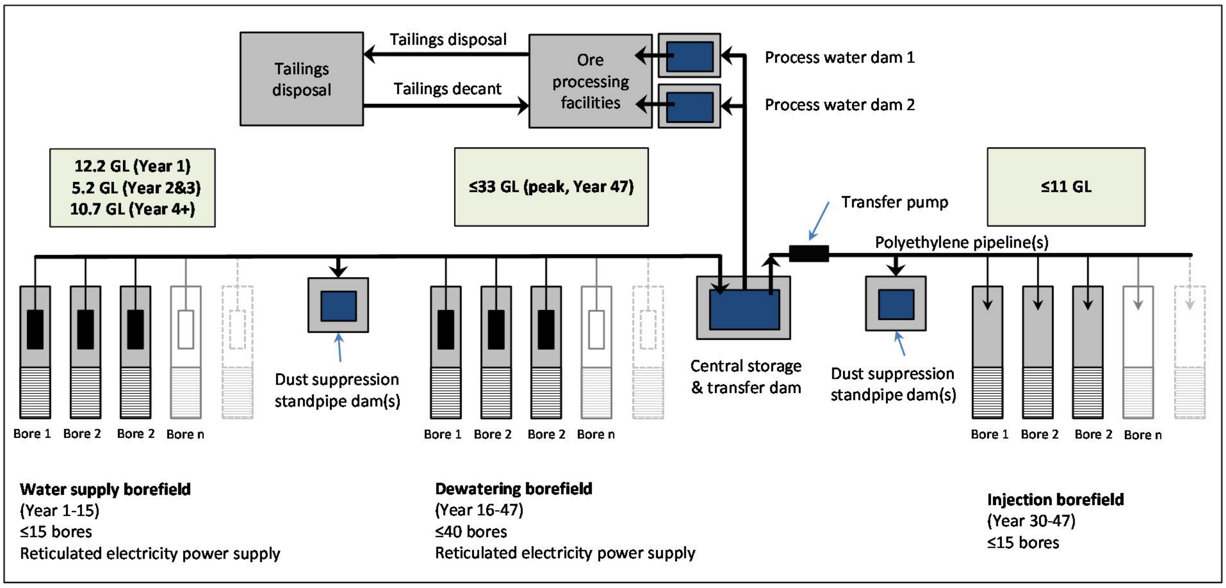


Figure 13: Conceptual Water Infrastructure Schematic

3.5.2.4 Borefield

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

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

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

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

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

3.5.2.5 Water Storages

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

Table 11: Mine Site Water Storages

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

3.5.2.6 Surface Water Drains and Diversions

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

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

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

3.6 OTHER KEY INFRASTRUCTURE

3.6.1 Power Supply and Distribution

3.6.1.1 Construction

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

3.6.1.2 Operations

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

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

3.6.2 Offices and Laboratory

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

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

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

3.6.3 Fuel Facilities

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

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

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

3.6.4 Maintenance Areas and Workshops

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

3.6.5 Wash Down and Waste Oil Facilities

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

3.6.6 Accommodation Village

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

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

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

3.6.7 Communication Services

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

3.6.8 Borrow Pits

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

3.6.9 Wastewater Treatment Plant

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

3.6.10 Solid Waste Management

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

3.6.11 Bioremediation Facility

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

3.7 SITE ACCESS AND PRODUCT TRANSPORT

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

Trucks will be used to deliver construction materials, supplies and remove selected waste streams. Buses and cars will be used for workforce transportation as required. The proximity to Derby and Broome means that no airstrip is required.
Bulk mineral product from the Mine Site will be loaded on to road trains and transported to Derby Port for export. Bulk product is expected to be transported using a fleet of quad road trains, each completing two trips per 12 hour

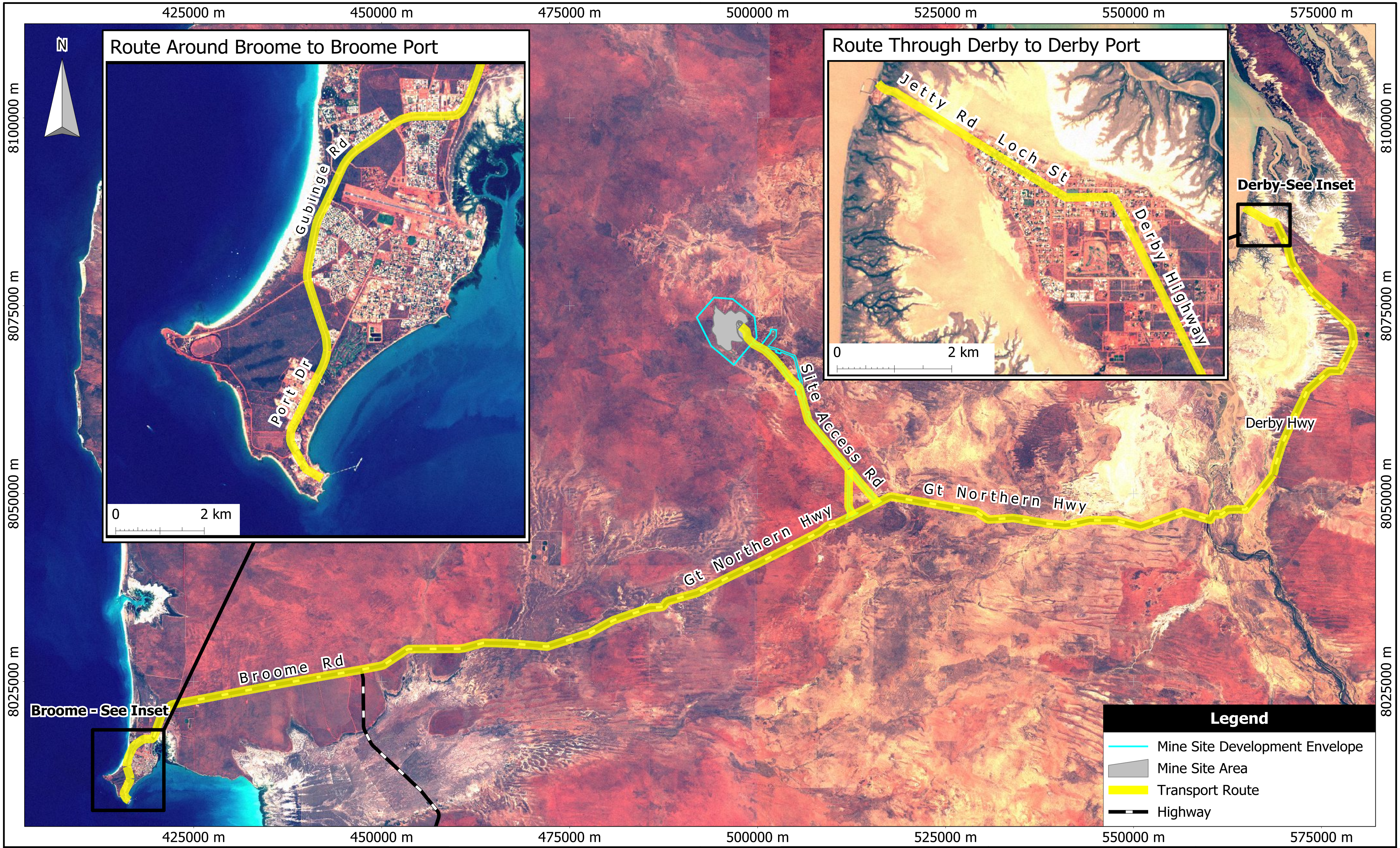
shift. Up to 10 return truck movements per day will occur between the Mine Site and Derby Port, operating 24 hours per day 7 days per week.

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

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

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

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



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

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Figure 14

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

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MBS ENVIRONMENTAL

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

3.8 PRODUCT EXPORT

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

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

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

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

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

3.8.1 Product Characteristics

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

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

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

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

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

3.8.2 Derby Port Infrastructure

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

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

Table 12: Derby Port Infrastructure and Proposed Modifications

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

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

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

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

3.8.3 Port of Broome Infrastructure

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

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

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

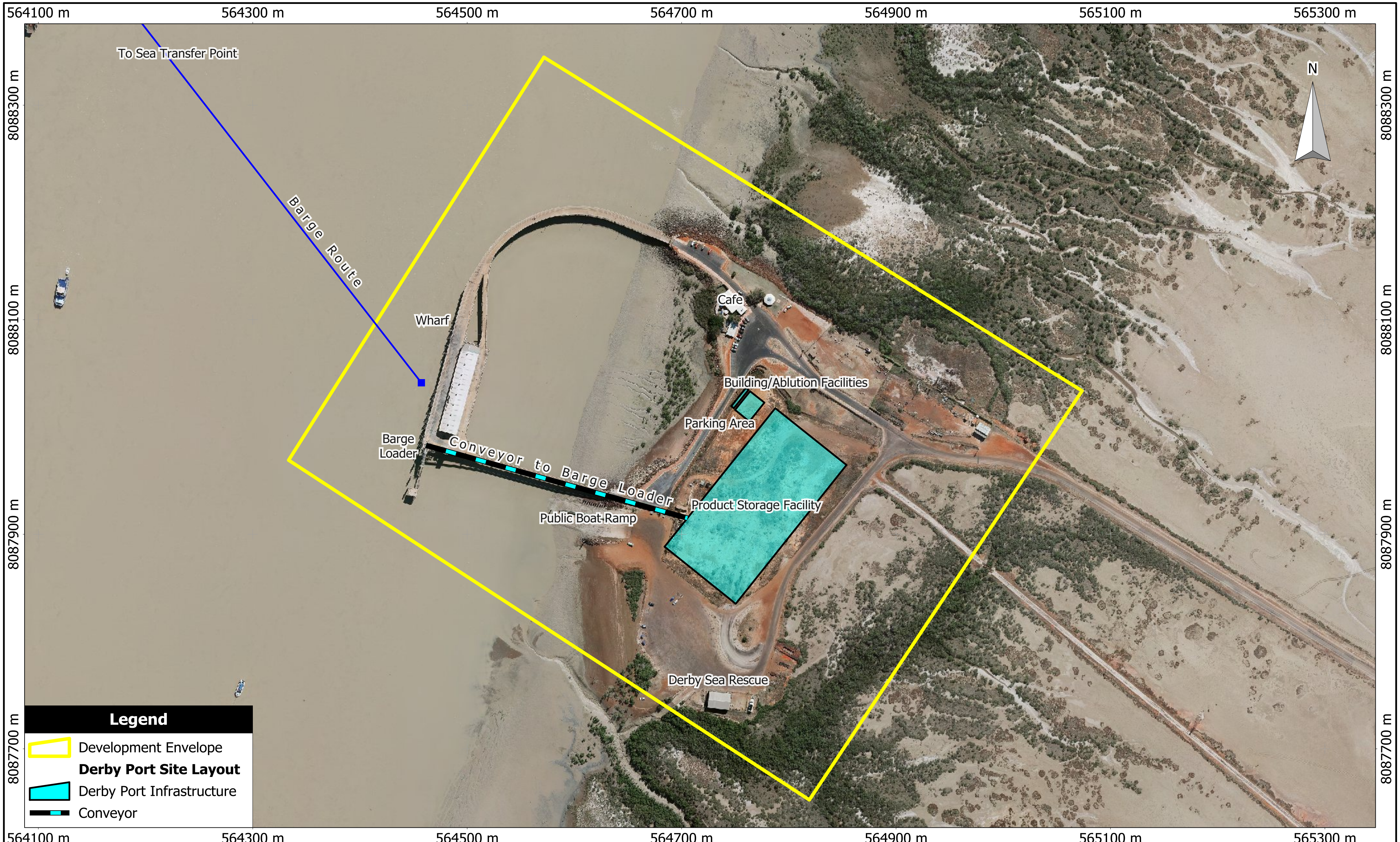
Existing wharf cranes and or vessel cranes will be used to transfer packaged product from trucks to an ocean-going vessel.

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

3.8.4 Derby Vessel Zones

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

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



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Grid: Australia MGA94 (51)

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Figure 15

Derby Port Development Envelope

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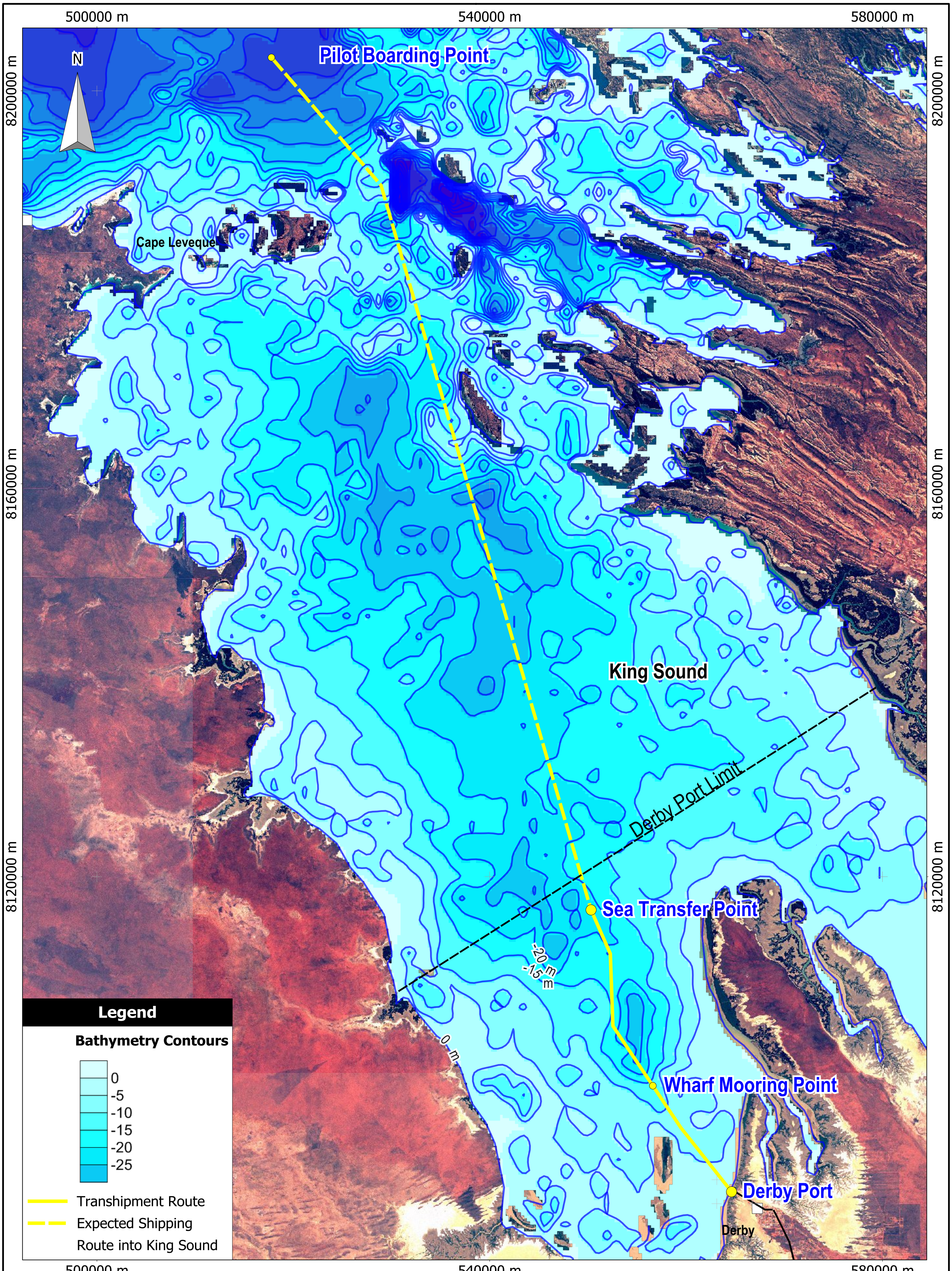

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Satellite Image:2016 Copernicus Sentinel Data
Grid: MGA94(51)
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Figure 16

Derby Port Mooring and Anchor Points

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3.8.5 Derby Port Transhipment Vessels

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

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

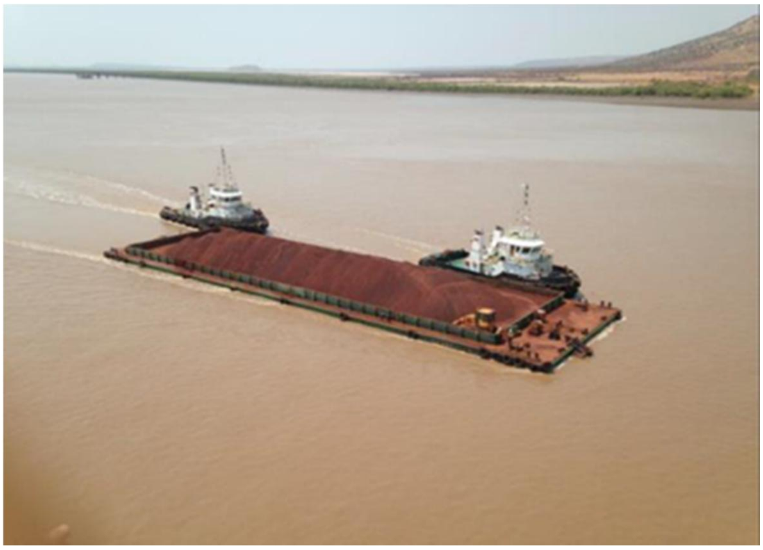

Plate 1: Typical Transhipment Vessel with Tugboats

3.8.6 Derby Transhipment Vessel Loading

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

3.8.7 Derby Ocean-going Vessel Loading

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

Plate 2: Typical Ocean-going Vessel Loading

3.8.8 Materials Handling Schedule

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

Table 13: Materials Handling Schedule

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

3.9 REHABILITATION AND CLOSURE

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

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

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

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

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

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

3.10 WORKFORCE

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