Government of Western Australia
Department of Water and Environmental Regulation

Amendment Notice 1

Works Approval Number	W6088/2017/1
Works Approval Holder	Thunderbird Operations Pty Ltd
ACN	611 351 743
File Number:	DER2017/001386
Premises	Thunderbird Mineral Sands Project Great Northern Highway WATERBANK WA 6725 Legal description – Tenements M04/459 and L04/85
Date of Amendment	8 October 2019

Amendment

The Chief Executive Officer (CEO) of the Department of Water and Environmental Regulation (DWER) has amended the above Works Approval in accordance with section 59 of the *Environmental Protection Act 1986* (EP Act) as set out in this Amendment Notice. This Amendment Notice constitutes written notice of the amendment in accordance with section 59B(9) of the EP Act.

Tim Gentle
Digitally signed by Tim Gentle
Date: 2019.10.08 17:21:25 +08'00'

Tim Gentle

Manager – Resource Industries

REGULATORY SERVICES

an officer delegated under section 20 of the *Environmental Protection Act 1986* (WA

Definitions and interpretation

Definitions

In this Amendment Notice, the terms in Table 1 have the meanings defined.

Table 1: Definitions

Term	Definition
AACR	Annual Audit Compliance Report
ACN	Australian Company Number
AER	Annual Environment Report
Amendment Notice	refers to this document
AS 4156.6 – 2000	Australian Standard AS 4156.6 – 2000: Determination of Dust/moisture Relationship for Coal.
Category/ Categories/ Cat.	categories of Prescribed Premises as set out in Schedule 1 of the EP Regulations
CEO	means Chief Executive Officer. CEO for the purposes of notification means: Director General Department Administering the *Environmental Protection Act 1986* Locked Bag 33 Cloisters Square PERTH WA 6850 info@dwer.wa.gov.au
Commission	means the process of operation and testing that verifies the Works and all relevant systems, plant, machinery and equipment associated with the processing plant, TSF and WWTP have been installed and are performing in accordance with Table 1
CS Act	*Contaminated Sites Act 2003* (WA)
CTD	Central Thickened Discharge
CUP	Concentrate Upgrade Plant
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.
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)
Existing Licence	The Licence issued under Part V, Division 3 of the EP Act and in force prior to the commencement of and during this amendment
Extreme rainfall event	1 in 100 year, 72 hour ARI rainfall event
m^3	cubic metres
Minister	the Minister responsible for the EP Act and associated regulations
MS	Ministerial Statement
MSP	Mineral Separation Plant
mtpa	million tonnes per annum
NEPM	National Environmental Protection Measure
Noise Regulations	*Environmental Protection (Noise) Regulations 1997* (WA)
Occupier	has the same meaning given to that term under the EP Act.
OECD	Organisation for Economic Co-operation and Development
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.
Professional Engineer	Means a person holding current certification from the Institution of Engineers Australian (IEAust)
Risk Event	as described in *Guidance Statement: Risk Assessment*
TSF	tailings storage facility
UDR	*Environmental Protection (Unauthorised Discharges) Regulations 2004* (WA)
WCP	Wet Concentrator Plant
Works Approval Holder	Thunderbird Operations Pty Ltd
WQPN #30	means the document *Water Quality Protection Note #30: Groundwater monitoring bores*, Department of Water (February 2006), Available at: www.water.wa.gov/au_data/assets/pdf_file/0010/4033/59685.pdf

Amendment Notice

This amendment is made pursuant to section 59 of the *Environmental Protection Act 1986* (EP Act) to amend the Works Approval issued under the EP Act for a prescribed premises as set out below. This notice of amendment is given under section 59B(9) of the EP Act.

This notice is limited only to an amendment for Category 8. No changes to the aspects of the original Works Approval relating to Category 54 or 89 have been requested by the Works Approval Holder.

The following guidance statements have informed the decision made on this amendment:

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

Amendment description

The Thunderbird Mineral Sands Project (Thunderbird) is a heavy mineral sands mining project located approximately 98 km northeast of Broome and 72 km west of Derby in Western Australia. Works Approval W6088/2017/1 was issued on 21 August 2018 for Stage1A for categories 8, 54 and 89. It included construction of a two stage mineral sands processing facility, construction of landfill, construction of wastewater treatment plant (WWTP) and bulk storage of chemicals.

Thunderbird submitted an application for an amendment to W6088/2017/1 on 21 September 2018 for Stage 1B to allow for the following:

- construction and operation of an above ground (out-of-pit) TSF
- disposal of tailings via an in-pit TSF; and
- construction of load out facilities.

The draft Amendment Notice was provided to the Applicant on 19 December 2018 for comment. However, a revised application was submitted on 14 January 2019 which provides additional details on the proposed deposition and embankment construction methodology for the initial above ground TSF. As such, the revised application supersedes the previous version and construction requirements will be in reference to the January 2019 report.

This amendment provides approval for construction of the initial above-ground TSF and construction of load-out facilities. Approval for the In-pit TSF will not be provided until a final decision is made on which of the three options will be used, as described in the section *In-pit Tailings Storage Facility* below. Disposal of in-pit tailings will be considered through a further amendment at a later date.

Central Thickened Discharge TSF

The proposed above ground TSF is a Central Thickened Discharge (CTD) system to allow for approximately 19 Mt of storage within three years. After three years, all tailings generated will be discharged into cells located within mine voids (in-pit TSF). This will ultimately provide storage for approximately 535 Mt of tailings.

The design concept for the initial TSF is to create a whaleback shape by cycling tailings deposition up and down a central deposition embankment (Williams 2019). Incidental rainfall and bleed water will drain by gravity to the low point within the TSF where it is decanted via gravity to an operational decant recovery pond located in an adjacent designated stormwater storage pond (SSP). This water will be recovered for reuse in the processing plant via a HDPE lined sump within the SSP (Williams 2019).

The decant system of the initial TSF comprises a series of drainage wells transferring supernatant water to a lined sump in the SSP via gravity pipelines. Any surface excess water will be transferred to the SSP via the TSF to SSP spillway (Williams 2019).

The Works Approval Holder has proposed to apply co-disposal techniques to allow for the placement of sand (79%) and slimes (21%) residue as a single deposition stream. Tailings will be delivered to the TSF at a solids concentration of approximately 50%. Strength gain and water release will be enhanced by the adoption of 'pipehead flocculation' techniques, whereby diluted flocculant or polymer is added to the tailings stream immediately before discharge to facilitate water recovery and to accelerate consolidation of the tailings.

The proposed flocculant is Magnafloc 155 (BASF), a high molecular weight anionic polyacrylamide (PAA) that is widely used in mineral processing and water treatment. Based on its structural properties, the polymer is not biologically available and accumulation is organisms is not expected to occur.

Slurry consolidometer tests were carried out and it is considered that for the case of in line flocculation proposed, which is anticipated to rapidly release up to 70% of the water contained in the slurry feed, the initial settled density of the tailings is likely to be approximately 1.4 t/m^3.

Provided control is maintained over the flocculant/polymer addition at the pipehead, the deposited strength is a much more significant factor and the resulting beach slope is typically much steeper than conventional deposits. The calculated beach slopes for the TSF are 7% (upper), 5% (middle) and 3% (lower).

The TSF will be constructed within an oval shaped impoundment surrounded by perimeter embankments, constructed in stages as deposition progresses. Tailings will be discharged from an elevated central causeway, along which the deposition point will move forwards and backwards on a cyclic basis, developing a 'whaleback' shaped stack. The predominantly sandy nature of the tailings and the rapid release of bleed water (promoted by in line flocculation of the slurry) is expected to result in a steep, rapidly draining beach. The causeway will be continually raised in approximately 5 m height increments as deposition cycles from one end to the other. Each deposition cycle comprises discharge from the southern side of the causeway on the downward stage followed by discharge from the northern side on the upward stage (Williams 2019).

As the Thunderbird tailings are thickened, they are expected to have high strength and the majority of decant water will be stored off the tailings surface. If sustained high rainfall filled the SSP to spillway level, the SSP embankments would temporarily contain up to 1 GL of water before being released via the emergency spillway.

The final heights of the TSF embankments will vary from 5.4 m high in the south to 11 m high in the north and the perimeter embankment will be approximately 4 km in length. The SSP embankment height will range from 3 m to 6 m and will have an emergency spillway.

Location of the CTD TSF is proposed to be immediately south of the processing plant, as shown in Figure 1.

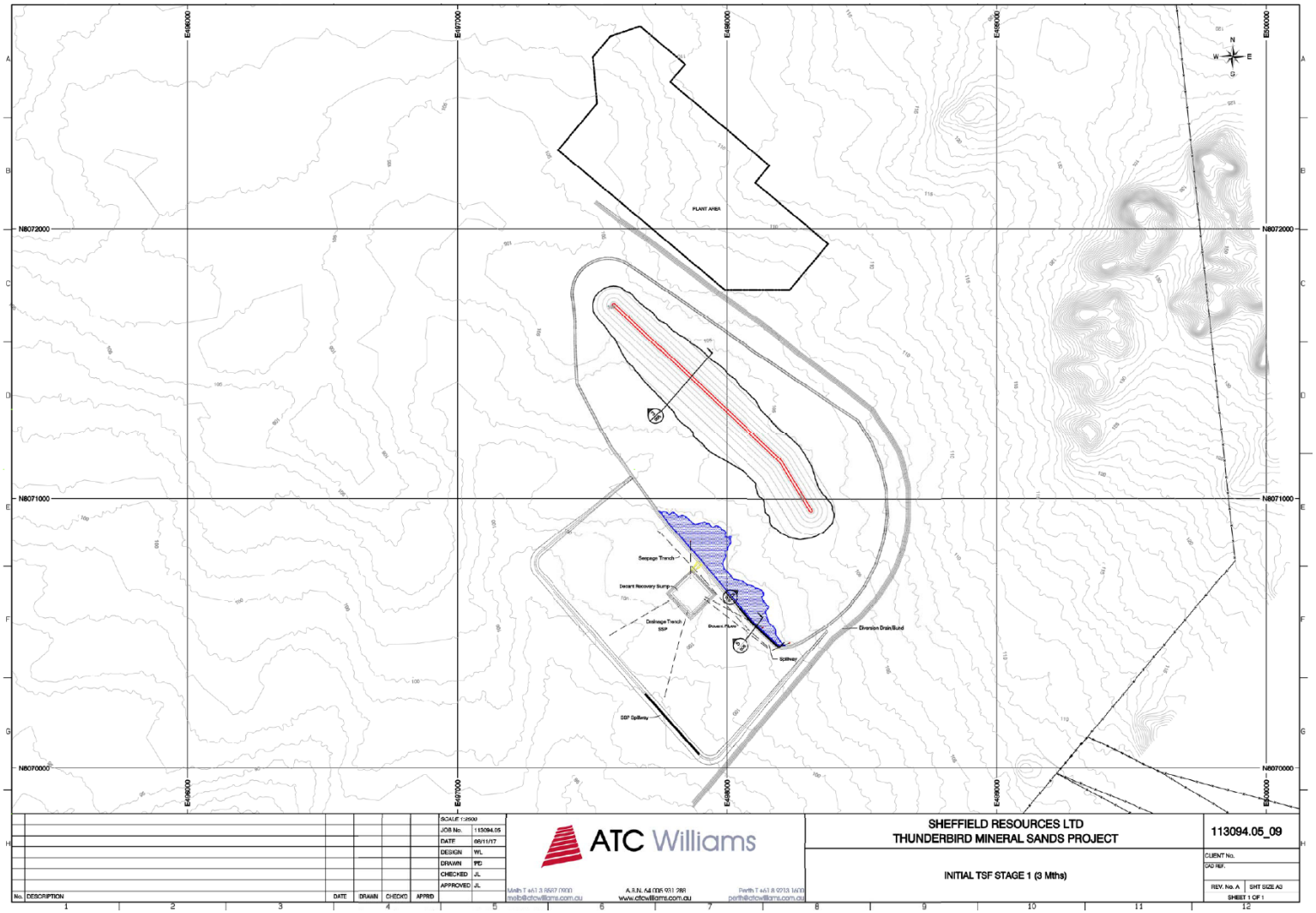


Figure 1: Location and Stage 1 (3 months) of initial TSF

In-Pit Tailings Storage Facility

The Works Approval Holder proposes to discharge tailings within mining voids once sufficient capacity is available. The Application details that discrete tailings cells will be constructed from dewatered sand tails, oversize material, or overburden material, within the mining void. As each cell reaches capacity, and is dried and consolidated sufficiently, final landform shaping and rehabilitation would be undertaken. Discharge spigots are moved around to enable maximum, efficient disposal within the cell.

The co-disposal tailings stream will be discharged to the cells at approximately 49.9% solids, with entrained water being recycled back to the process plants, and approximately 40% lost to seepage and evaporation. The disposal of in-pit tailings will provide tailings storage over the majority of the life of mine.

The Works Approval Holder has identified in the Application that a variety of tailings containment conditions will be encountered throughout the life of mine. Containment is required for the tailings, water emanating from the tailings and stormwater from incidental rainfall. Containment conditions include:

- Containment provided by the outer pit walls.
- Containment adjacent to un-mined sections of the pit.
- Containment adjacent to the active mining area.

In order to facilitate these conditions, several deposition procedures are anticipated to be required depending on specific configuration of the area for deposition.

Full Containment

The full containment option is to provide full height containment of tailings in order to separate the deposition area from the adjacent un-mined ore and from the active mining area. Deposition would occur from the embankments adjacent to the mining area towards decant recovery adjacent to the pit wall. As the tailings surface reaches the crest of the embankment, the discharge location will be progressively moved towards the decant recovery location. Stormwater storage will be maintained within the concave tailings surface by limiting the fill depth of the tailings. If over-filling is required to generate the final landform design, this will be achieved by increasing the embankment heights and providing bunding around the pit perimeter.

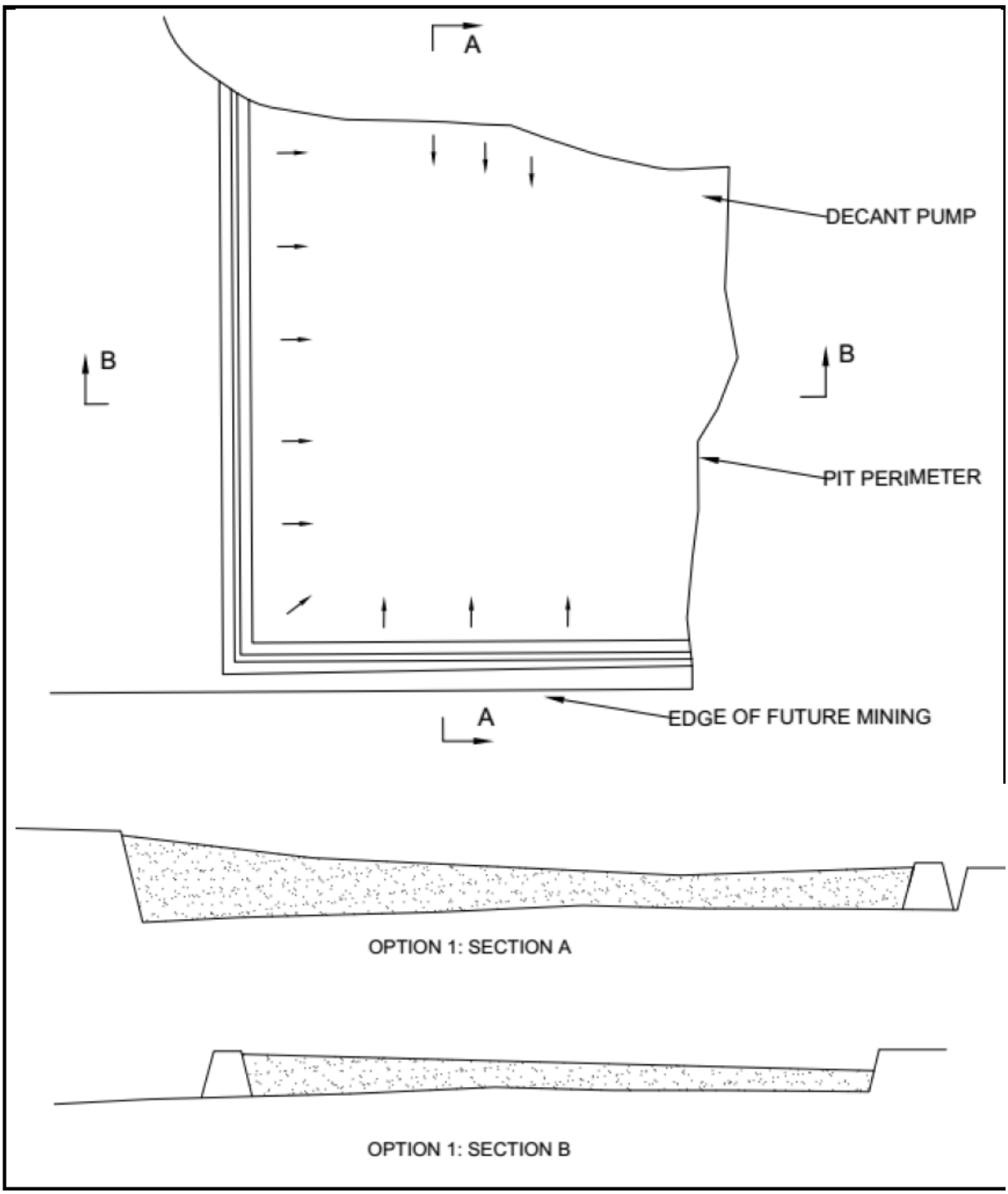


Figure 4: Full containment and deposition

Cross Pit Embankment Containment and Deposition

This option would avoid the need for a significant embankment along the face of the future mining area, but will require future excavation of the tailings against the un-mined ore. Excavated tailings would initially be stockpiled then placed into the mining void behind the mining unit. Deposition would occur from the embankments adjacent to the mining area towards decant recovery adjacent to the pit wall.

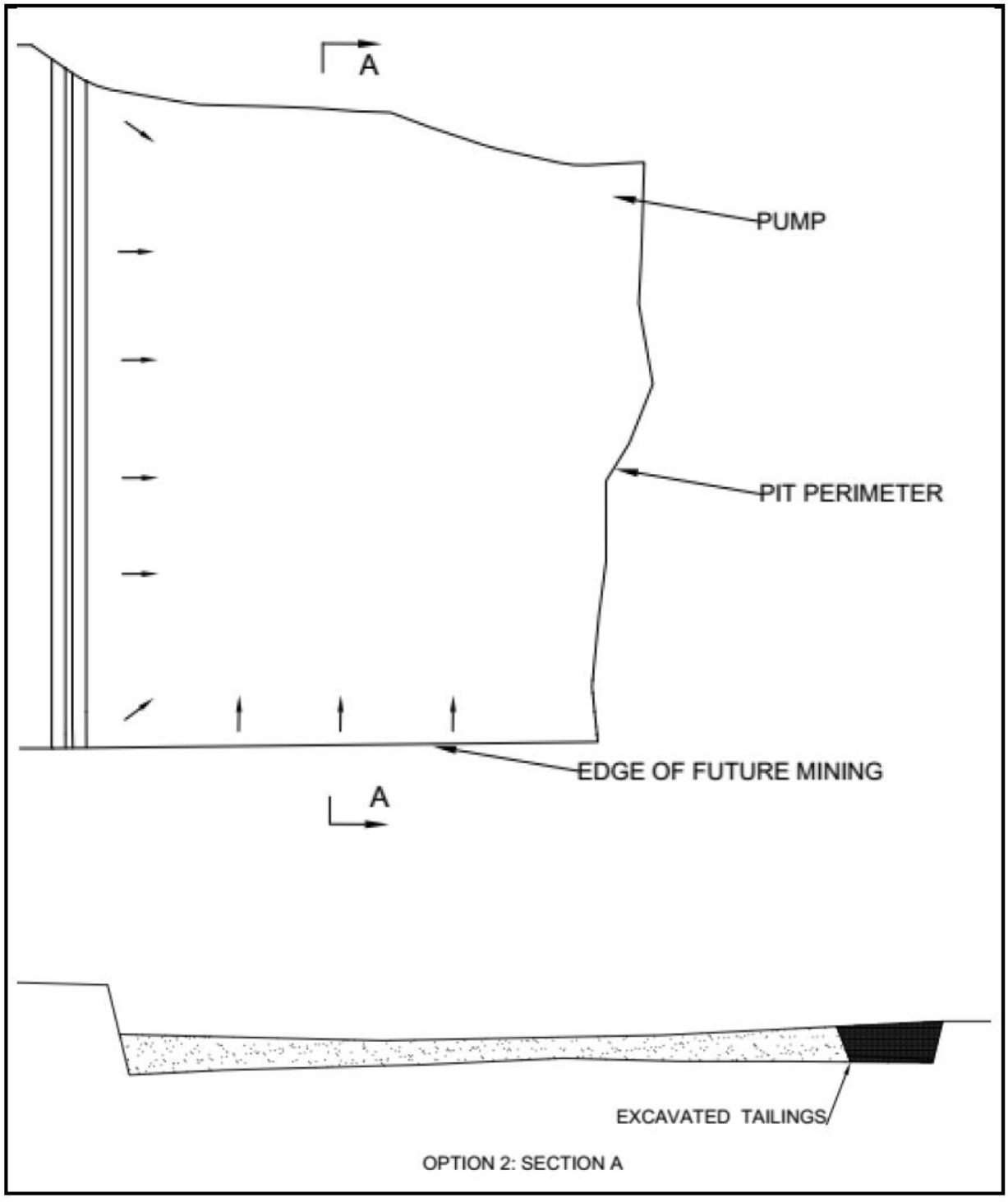


Figure 5: Cross pit embankment containment and deposition

Discharge Spline Embankment Containment and Deposition

This option involves construction of an embankment to form a 'central' discharge spline plus containment bunds along the toe of the un-mined ore, and to separate the tailings area from the active mining area. Tailings discharge would commence at the end of the pit and progress towards the active mining area. Initially storm water storage would be provided within the bunded area, but as the tailings surface progresses, additional storage will be provided behind the active mining area. The spline crest elevation will be determined to provide sufficient over-filling to allow for tailings consolidation and filling of zones with insufficient fill during closure.

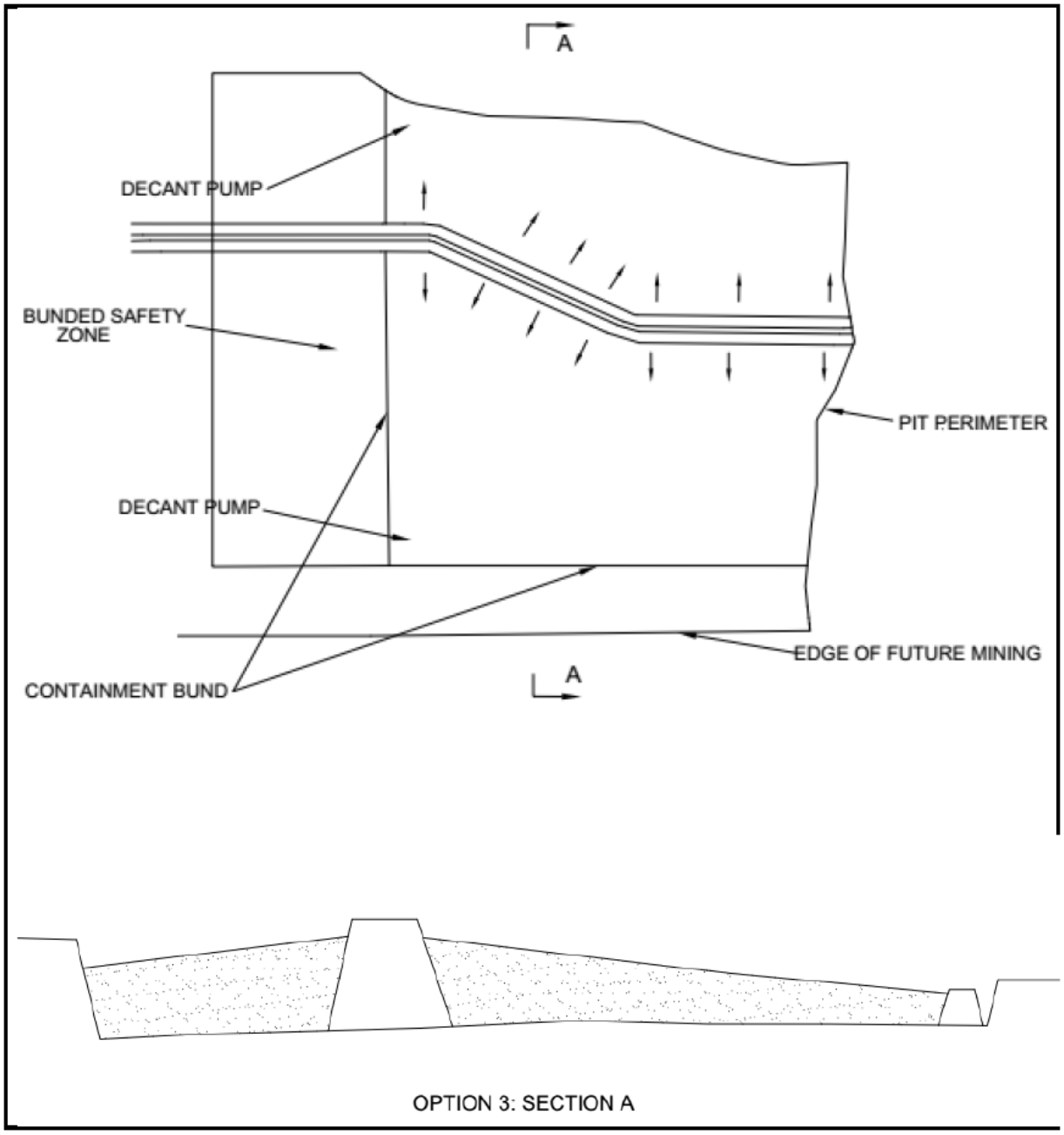


Figure 6: Discharge spline embankment containment and deposition

Cross Pit Containment and Deposition

This option is similar to the discharge spline embankment containment and deposition except that the elevated discharge embankment is located on the perimeter of the pit. This option involves construction of containment bunds along the tow of the un-mined ore, and to separate the tailings area from the active mining area. Tailings discharge would commence at the end of the pit and progress along the active pit perimeter. Stormwater storage would be provided within the bunded area. A bunded safety zone will be maintained between the tailings area and the active mining area. Bunded walls will require water retaining design criteria, and sufficient design stormwater storage capacity.

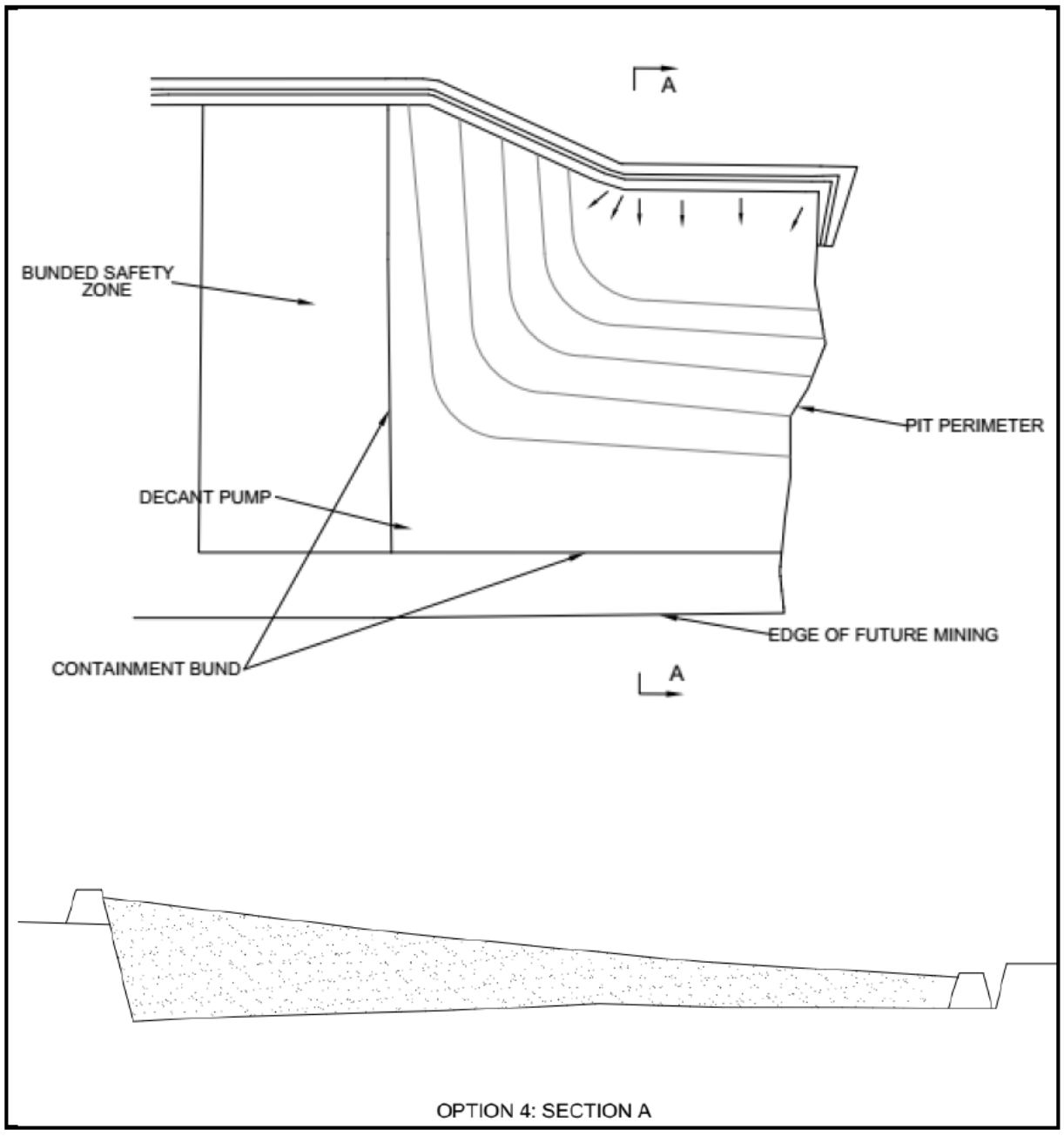


Figure 7: Cross pit containment and deposition

The Applicant has provided a figure (Figure 8) which shows the pit void at the end of the first three years of mining. Two cells have been considered for the initial stages of in-pit tailings storage, known as Cell 1 and Cell 2. In-pit deposition will commence at Cell 1, utilising a cross pit containment option (option 4) along the north western wall of the pit. Whilst deposition is occurring here, active mining will be downstream of Cell 2. Approximately three months of tailings can be stored before the tailings level reaches the discharge point elevation.

Deposition of tailings will then switch to Cell 2, allowing sufficient time for tailings to consolidate in Cell 1. Discharge into Cell 2 will be via a spline embankment (option 3). This embankment construction could be staged. Deposition of tailings could switch back to Cell 1 while raising the spline embankment of Cell 2.

Deposition of tailings from the northern wall of Cell 1, then along the access ramp will provide approximately one month of operation, at which time deposition can be switched back to Cell 2. Once the tailings elevation reaches the design level and sufficient time has elapsed for Cell

1 tailings drying and consolidation, a spline embankment could be constructed over the deposited tailings and tailings deposition could be carried on along the spline embankment. After this stage, tailings deposition will continue into Cell 2.

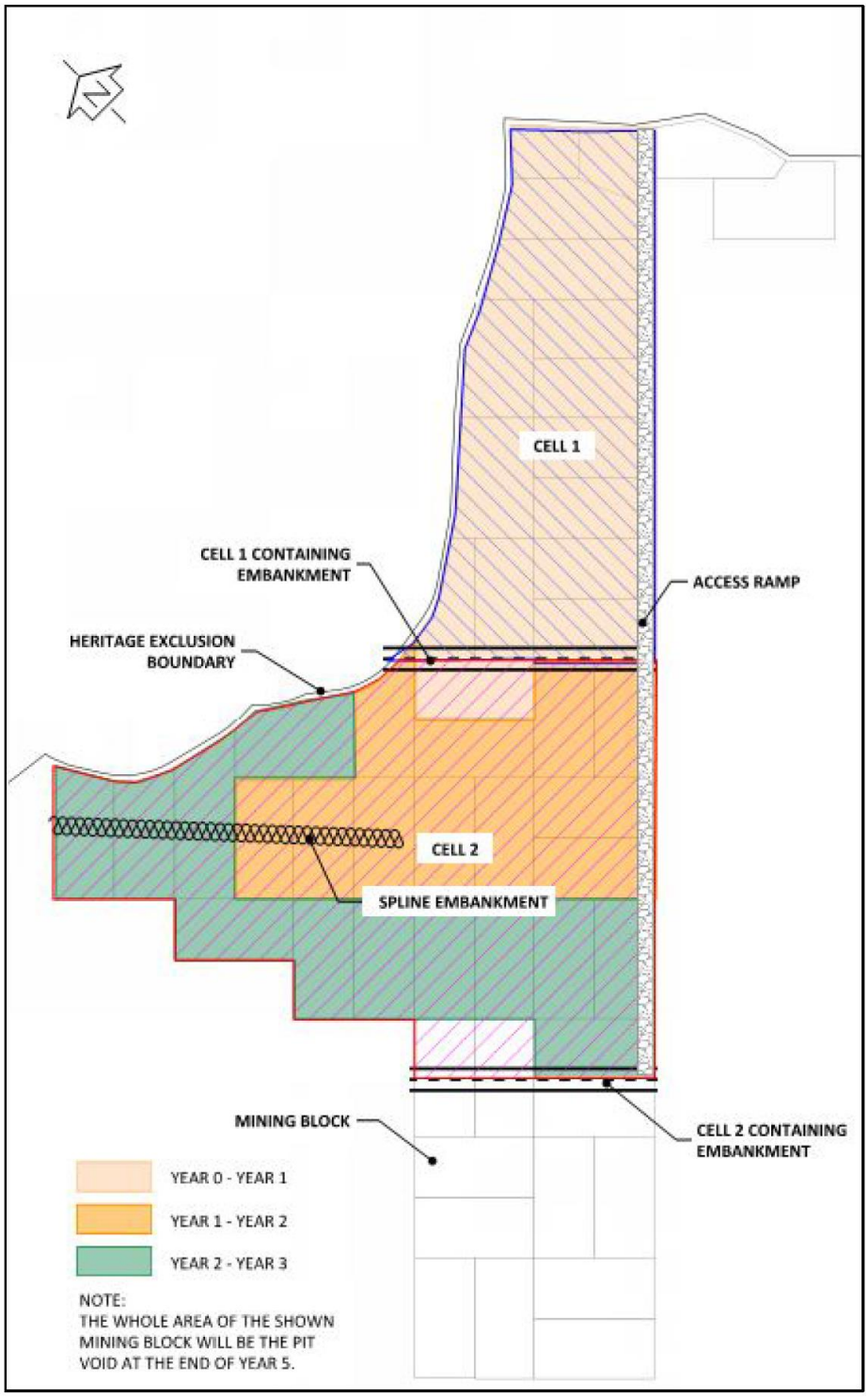


Figure 8: In-pit available void after three years of mining

The Application also includes a figure (Figure 9) to depict a tailings deposition timeline. However, it is noted that the timeline is preliminary and could change during the operation depending on design and operation requirements.

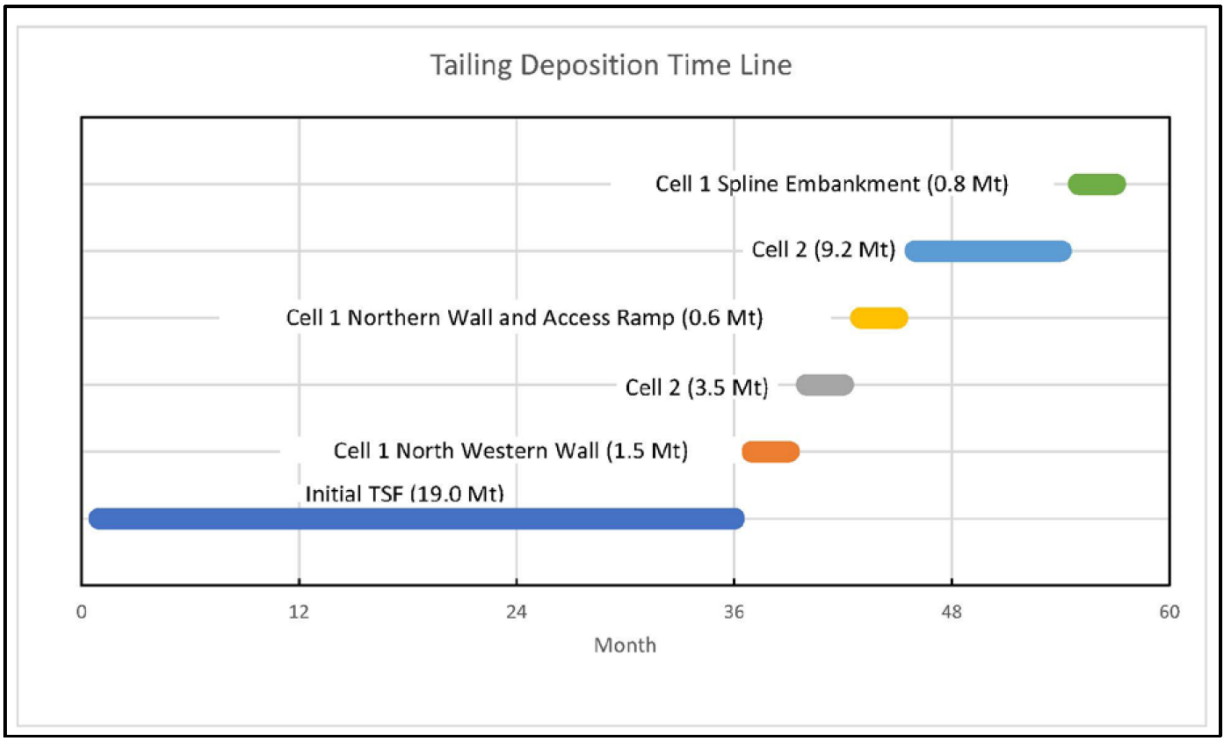


Figure 9: Tailings deposition timeline

Tailings Characteristics

The Application identifies that tailings from the Wet Concentrator Plant (WCP) and Mineral Separation Plant (MSP) will be stored within the CTD TSF initially followed by disposal into the into the mine void. Table 2 summarises the waste streams and quantities versus mined material.

Table 2: Waste streams and quantities versus mined material

Residue Stream	Description and Fate	Stage I (7.5 Mtpa)	Stage II (15 Mtpa)	Percentage of Processed Material
MUP >5.0mm Oversize	Mining Unit Plant Oversize (> 5 mm). Stockpiled for use as roadbase/construction or returned to mine void.	300 ktpa	600 ktpa	4%
MUP/WCP >2.0 mm Oversize	Mining Unit Plant Oversize (> 2 mm). Stockpiled for use as roadbase/construction or returned to mine void.	750 ktpa	1,500 kpta	10%
MUP/WCP sand rejects	Waste non heavy mineral sand returned to mine void or initial TSF. Assessed in mine waste report (MBS 2016).	5,097 ktpa	10,194 ktpa	68%
WCP tails (slimes)	Wet Concentrate Plant Tails (initial gravity separation slimes/clay fraction). Returned to mine void or initial TSF	565 ktpa	1,130 ktpa	7.5%
CUP MSP tails	Concentrate Upgrade Plant Combined Tails (magnetic separation) and MSP tails. Returned to mine void or initial TSF.	325 kpta	649 kpta	4.3%
MSP rejects	Minerals Separation Plant Rejects (includes zircon plant rejects and ilmenite processing rejects). Returned to mine void or initial TSF.	142 ktpa	283 ktpa	1.9%
Gypsum	Acid neutralisation residue from HAL circuit. Gypsum evaporation pond and/or mine void.	1.9 ktpa	3.7 ktpa	0.025%
Products exported (ilmenite, zircon, and HiTi88) or stockpiled (magnetic concentrate)		322 ktpa	644 ktpa	4.3%

The Works Approval Holder collected six samples of processing residue from pilot processing trials for geochemical assessment. They consisted of two samples of oversize material from the Mining Unit Plant screening of the silicified mineral sands (>2 mm and >5 mm), individual samples of MSP, CUP and WCP tailings/reject materials and a gypsum waste stream generated from neutralisation of the hot acid leach residue using agricultural lime (calcium carbonate). The samples were collected and tested for:

- acid base accounting:
- elemental composition:
- water leachate characterization:
- dilute acid leachate characterization;
- mineralogical assessment of gypsum residue; and
- particle size analysis and potential for dispersion

The overall results, concluded that project tailings will be non-acid forming and barren with

essentially no capacity for acid generation or acid neutralisation. Predicted concentrations of soluble salts, metals and metalloids in seepage are expected to be low. Low overall levels of calcium sulfate and calcium carbonate will gradually be mobilised by leaching from the 'gypsum' residue, however seepage water quality will mostly reflect process groundwater quality as drawn from local aquifers. Various residues are geochemically enriched in thorium, uranium, lead and selenium, however, these elements were not found to be mobile, even under artificially applied acidic conditions.

Product Load Out Facilities

The Works Approval Holder is proposing to construct product load out facilities to ensure appropriate storage and loading prior to transport of product off-site where it will be taken to ports either in Broome or Derby for export, as demonstrated in the below table.

Table 3: Products to be exported from either Broome or Derby

Thunderbird Product	Minesite Storage	Road Haulage	Port of Export & Storage	Product Export Method
Titano-Magnetite	Bulk in enclosed shed	Quad enclosed trailer road-train	Derby – enclosed shed	Bulk Shipment
Zircon concentrate				
LTR Ilmenite				
Ilmenite				
Hi-Ti88	Bagged in enclosed shed	Quad or triple covered trailer tautliner road-road-train	Broome – enclosed shed	FIBC Bulk Bags
Premium Zircon				

Packaging of premium zircon and HiTi-88 into 2 tonne FIBC bulk-bags will occur at the Mine Site, within a dedicated bagging facility, on a continuous basis as the final product becomes available for processing. Bagged product will then be stored in the bag storage shed until collection by standard covered 'tautliner' road trains. Forklifts will load bags onto the trailers from both sides whilst the full road train is parked inside the bag storage shed.

Bulk products will be stored in enclosed segregated sheds awaiting collection by purpose-designed, quad-trailer road trains dedicated to the Mine Site-Derby route. Front end loaders will reclaim the stored bulk product into the bulk haulage trailers whilst inside the storage shed.

Commissioning Stages

As part of the Amendment Application, the Works Approval Holder has requested commissioning be included as this was not included in the original application, due to the TSF not being assessed at that time.

There are five construction and commissioning stages that have been proposed:

- Phase 1: Construction water and mine access roads
- Phase 2: Accommodation village and water, wastewater and landfill facilities
- Phase 3: Initial TSF
- Phase 4: Process plant (Stage 1), in-pit tailings disposal and associated pipelines
- Phase 5: Process plant (Stage 5).

Table 4 shows the proposed construction and commissioning schedule.

Table 4: Construction and commissioning schedule

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 1)	4 weeks	6 months following completion of stage 2
		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	TSF	Quarter 2, 2020	100 weeks	16
4	Process plant (WCP1 and MSP 1) and TSF	Quarter 3, 2020	110 weeks	16
5	Process Plant (WCP2 and MSP2)	Quarter 1, 2024		

The Works Approval Holder has proposed three commissioning phases:

- Pre-commissioning – comprising static checks on unpowered equipment to confirm that the infrastructure has been built in accordance to specifications.
- Dry commissioning – comprising test operation of 'empty' equipment and facilities without the additions of fuel, reagents, ore, water or air.
- Wet commissioning – comprising 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 will be gradually increased until they reach the stead-state design volumes.

Other approvals

The Works Approval Holder has provided the following information relating to other approvals as outlined in Table 5.

Table 5: Relevant approvals

Legislation	Number	Approval
Part IV of the EP Act	Ministerial Statement 1080	Ministerial approval for implementation of the proposal (to construct and operate Thunderbird mine)
Part V of the EP Act	W6072/2017/1	Works Approval to allow minor and preliminary works to be undertaken. This included the development of two geotechnical trenches and to allow construction and operation of a waste water treatment plant and landfill.
Mining Act 1978 (WA)	Mining Proposal 76994	Mining approval – Mining Proposal RegID

		76994 was approved on 13 September 2019.
Rights in Water and Irrigation Act 1914 (WA)	CAW 021251(1)	Approval to construct 15 production bores in Canning-Kimberly Groundwater Area, Canning-Broome aquifer
Environment Protection and Biodiversity Conservation Act 1999 (Cth)	Decision Notice EPBC 2016/7648	Decision Notice approval granted on 27 September 2018 for construction and operation of Thunderbird with conditions

Consultation

The Application was referred to relevant stakeholders, with comments summarised in Table 6.

Table 6: Consultation

Submitter	Comment
Shire of Broome	No submission received
Yeeda Pastoral Lease Holder	No submission received
Traditional Landowner	The comments relate to the entire mining proposal rather than the specific amendment application. In summary, the comments were in regards to the global significance of the Fraser River drainage basin and its geo-heritage value. However, the submission made no specific reference to the above-ground TSF, which is the main subject of the works approval amendment. The comments provided were generally relevant to the Part IV assessment, not Part V. Therefore, they are not considered relevant to this Application.

Location and receptors

Table 7 below lists the relevant sensitive land uses in the vicinity of the Prescribed Premises which may be receptors relevant to the proposed amendment.

Table 7: Receptors and distance from activity boundary

Residential and sensitive premises	Distance from Prescribed Premises
Mt Jowlaenga homestead (currently unoccupied)	Approximately 7 km from the Premises
Nillibubbica designated rest area, Great Northern Hwy	Approximately 27 km from the Premises
Bidan (formerly known as Bedunburra) Aboriginal Community	Approximately 28 km from the Premises
Yeeda Outstation, Mt Jowlaenga Rd	Approximately 28 km from the Premises

Table 8 below lists the relevant environmental receptors in the vicinity of the Prescribed Premises which may be receptors relevant to the proposed amendment.

Table 8: Environmental receptors and distance from activity boundary

Environmental receptors	Distance from Prescribed 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 mudflaps. The closest mapped PECs include the Lowangan Land System (21 km east); Vegetation Association 67 (35 km south and north).
Threatened/Priority Flora	No declared rare or threatened flora pursuant to the WC Act or EPBC Act have been recorded within M04/459 Two Priority Flora species have been recorded within M04/459 (none within the 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. 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. During a targeted Greater Bilby survey, over 750 records of Greater Bilby activity were recorded within proximity to M04/459.
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. 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 tributaries enter the mining tenement boundary to the north however are more than 1.5 km from the TSF and associated pipelines. In addition there is a catchment divide between these tributaries and the TSF.
	The headwaters of Fraser River South is located approximately 4 km south of the Premises.
	The Fitzroy River is located approximately 71 km south-east of the Premises.
Groundwater	Depth to groundwater over the test pits is around 36 to 38 metres. The salinity in groundwater is low (110 – 200 mg/L TDS).

Hydrogeology

Broome aquifer

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 conductivity. It is a major unconfined to semi-unconfined 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 (Application 2018).

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. The Works Approval holder has confirmed that the depth to groundwater in the Broome Aquifer is 20 m or more across the site.

A localized 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 Broom aquifer.

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 *Eucalyptus tecifica* open woodland over sparse tussock grassland or sedgeland. Groundwater levels in the Broome aquifer are about 18 m below ground level 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.

Risk assessment

Tables 9 and 10 below describe the Risk Events associated with the amendment consistent with the *Guidance Statement: Risk Assessments*. Both tables identify whether the emissions present a material risk to public health or the environment, requiring regulatory controls.

Table 9: Risk assessment for proposed amendments during construction and commissioning

Risk Event						Consequence rating	Likelihood rating	Risk	Reasoning
Source/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*	Civil excavation/vehicle movements on unsealed roads Construction of initial above ground TSF Construction of in-pit TSF Commissioning of mining infrastructure - plant and TSF	Noise Fugitive dust	Human receptors: Mt Jowlaenga Station (8 km) Nillibubbica rest stop (27 km) Kimberly Meat Co. (28 km) Bidan Aboriginal Community (28 km) Yeeda Outstation (28 km)	Air/wind dispersal	Health and amenity impacts	N/A	N/A	N/A	No credible risk of health and amenity impacts based on the distance to sensitive receptors.
		Oxidation of Acid Sulfate Soils from physical disturbance of ASS material	Groundwater, groundwater dependent vegetation	Leaching from in situ ASS material	Groundwater contamination (acidification)	N/A	N/A	N/A	The risk of disturbing ASS from excavations is Low, as production works including commissioning will not extend below the natural water table.
	Construction of load out facilities	Noise Dust	Human receptors: Mt Jowlaenga Station (8 km) Nillibubbica rest stop (27 km) Kimberly Meat Co. (28 km) Bidan Aboriginal Community (28 km) Yeeda Outstation (28 km) Flora and fauna in close proximity (dust only)	Air/wind dispersal	Health and amenity impacts	N/A	N/A	N/A	No credible risk of health and amenity impacts based on the distance to sensitive receptors.

Table 10: Risk assessment for proposed amendments during operation

Risk Event						Consequence rating	Likelihood rating	Risk	Reasoning
Source/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*	Disposal of mine tailings (to initial above ground TSF)	Seepage of water entrained within tailings to groundwater	Groundwater and groundwater dependent ecosystems/vegetation.	Lateral or vertical seepage of leachate through base of TSF	Contamination of groundwater, impacting on any groundwater depending ecosystems Groundwater mounding	Moderate	Unlikely	Medium	Groundwater in the vicinity of the CTD TSD is more than 20 mbgl (Deeper Broome Sandstone aquifer). Whilst there are areas of perched groundwater they are not connected to the Deeper Broome Sandstone aquifer. Due to the separation distance, the Delegated Officer considers the likelihood of the event occurring to be unlikely. However, the overall risk has been determined as Medium, therefore there will be some regulatory control in the form of Licence condition to allow for the management of potential emissions. Mineral sands tailings include wastes from wet concentrator plant (sand rejects and clay slimes). The design of the above ground TSF is for tailings distribution to be cyclic over the full footprint of the storage and evaporative drying following placement results in tailings becoming only partially saturated, which in turn limits downwards seepage gradients and quantities. Runoff will be collected at the toe of the beach and will flow via gravity to form a decant pond at the low point of the tailings impoundment area. This water will then flow into a concrete decant collection sump which will transfer the water via gravity drainage pipes to a HDPE lined recovery pond in the SSP. Since water is not stored on the tailings surface, except for

									a minimal operating pond required in order to avoid scouring out of tailings, and as the tailings material will be relatively well drained, the upper part of the tailings surface is not expected to be saturated. Excess rainfall from cyclones and large rainfall events will runoff the tailings surface to the decant area. It is estimated that infiltrating water will penetrate the surface at a maximum rate of <4 mm/hour. It is therefore considered, that the facility can effectively manage tailings containment during large rainfall events and containment provisions for such events are incorporated into the design. Combined with evaporative drying, the anticipated steep tailings beaches, rapid release of bleed water and rapid consolidation of tailings (due to the addition of flocculent), it is expected the potential for tails leachate seepage to be minimal (Williams 2019). In addition to the adoption of the above, the Works Approval Holder has proposed the following seepage management contingency measures: • Installation of three monitoring bores outside the TSF footprint which is be sampled prior to the commencement of deposition and then quarterly during the life of the project; • Excavation of seepage collection trenches that collect seepage through the upper layers of the foundation which will be pumped out and the water subsequently used in the processing facility; • Embankment foundation cut-off keyways to minimize embankment seepage: and • Installation of piezometers within the tailings to monitor the phreatic surface therein. If seepage occurs beyond the toe of the embankments, shallow seepage collection trenches will be excavated to intercept such seepage and return collected water to the cell decant collection areas. DWER has considered the Works Approval Holder's proposed seepage management controls and has determined that three monitoring bores will be insufficient for the design of the TSF. It is important that sufficient bores are installed to determine both the concentration and spatial distribution and magnitude of contamination concentrations in groundwater, as well as the direction and rate of groundwater flow between the source of contamination and a receptor. DWER requires a minimum of five monitoring bores, including four bores to monitor groundwater quality and to assess the direction of groundwater flow near the facility and an additional bore to monitor background groundwater quality. A condition to the Works Approval will be included with this requirement. A TSF Operations Manual will be developed and implemented to provide direction for operation. The Delegated Officer has taken into consideration the

									contingency measures in place by the Works Approval Holder along with the depth to groundwater, the adoption of central thickened discharge and the geochemical assessment carried out on tailings samples. Groundwater monitoring of the following parameters will be required through licence conditions to identify whether any seepage to groundwater is occurring: Standing water level pH Electrical conductivity Redox potential Titratable acidity Total alkalinity Major ions (bicarbonate, calcium, chloride, magnesium, potassium, sodium, sulfate, total dissolved solids) Metals and metalloids (aluminum, arsenic, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, nickel, radium, selenium, total beta, total alpha, thallium, uranium, vanadium and zinc)
Category 8 *Mineral sands mining or processing: premises on which mineral sands ore is mined, screened, separated or otherwise processed*	Disposal of mine tailings (to initial above ground TSF)	Contaminated surface water runoff	Native vegetation associated with drainage lines, surface water or shallow groundwater	Direct discharge	Contamination of drainage lines, inhibiting vegetation growth and survival Erosion and sedimentation	N/A	N/A	N/A	The risk of contaminated surface water runoff causing off-site impacts is considered Low, based on the sandy soils with low average annual runoff coefficients (0.00 – 0.07) and the implementation of surface water control measures proposed by the Applicant, including the construction of the SSP.
	Disposal of mine tailings (to initial above ground TSF)	Pipeline rupture or failure causing tailings discharge to land	Native vegetation associated or drainage lines associated with surface water or shallow groundwater	Direct discharge	Contamination of drainage lines, inhibiting vegetation growth and survival	Moderate	Possible	Medium	The Works Approval Holder has committed to manage pipelines with the following methods: • Pipelines will be HDPE with welded joints or compression fittings. The slurry pipelines will have flanges at approximately 60 m intervals. • Pipelines will be above ground and located within earthern bunds; • Sumps will be located at low points along the pipeline routes to contain any material which is leaked; • If required, some sections will be buried to prevent damage from vehicles or interference of surface drainage. All buried pipework will be signed. Conditions will be imposed on the Licence for management of pipelines.
	Disposal of mine tailings (to initial above ground TSF)	Overtopping/breach of containment causing discharge to land	Native vegetation associated or drainage lines associated with surface water or shallow groundwater	Direct discharge	Inundation of surrounding soils or contamination of drainage lines, inhibiting vegetation growth and survival	Moderate	Unlikely	Medium	The TSF has been designed in accordance with DMIRS and ANCOLD guidelines to ensure the facility can operate during a 1:100 AEP 72 hour rainfall event. The TSF will operate with at least 0.5 m freeboard. Licence conditions for freeboard and inspections of infrastructure will be included.
		Creation of a supernatant pond	Attraction of wildlife including migratory birds to supernatant ponds.	Interaction of wildlife with the supernatant pond	Toxicological impacts to wildlife from consuming potentially toxic supernatant water.	Minor	Rare	Low	Elemental composition testing carried out stated that thorium, uranium, vanadium and lead were well below livestock and drinking guidelines, indicating they're present in stable, insoluble forms. Leachate tests showed uranium and thorium were highly insoluble and environmentally unavailable. The polyacrylamide (PAA) is composed of carbon, hydrogen, oxygen and nitrogen and does not contain other elements such as phosphorus and sulphur often found in other surface active substances. PAA degrades slowly in the environment, although it is not classified as readily biodegradable by OECD criteria. It is unlikely to result in

									oxygen depletion of surface and groundwaters. It is not particularly toxic to aquatic organisms. It is not expected to migrate from mineral sands process tailings through 20+ m of soil/regolith to groundwater at any concentrations approaching aquatic toxicity due to strong adsorption to process tailings, humic substances and clay minerals. It is not biologically available and accumulation in organisms is not expected. PAA has also been approved by the National Health & Medical Research Company as a chemical recommended for us in the treatment of drinking water through the Australian Drinking Water Guidelines 6 2011. As such, the risk to wildlife including migratory birds is deemed low.
Category 8 *Mineral sands mining or processing: premises on which mineral sands ore is mined, screened, separated or otherwise processed*	Stormwater storage pond	Overtopping/breach of containment causing discharge to land	Native vegetation associated or drainage lines associated with surface water or shallow groundwater	Direct discharge	Inundation of surrounding soils or contamination of drainage lines, inhibiting vegetation growth and survival	Moderate	Unlikely	Medium	The SSP has been designed to contain the run-off volume arising from a 1:100 year, 72 hour storm event with the storm water run-off on the tailings beach being progressively discharged to the pond, via a spillway. Licence conditions for freeboard and inspections of infrastructure will be included.
	Disposal of mine tailings to in-pit mine voids. Includes: - Wet concentrator plant (WCP) sand rejects -WCP clay slimes -Combined CUP and Mineral Separation Plant (MSP) tailings -MSP rejects -Gypsum (acid neutralization residue from HAL circuit)	Seepage of water entrained within tailings via base of mine void to groundwater	Groundwater and groundwater dependent ecosystems	Lateral or vertical seepage though base of mine void	Groundwater contamination and/or mounding	Moderate	Unlikely	Medium	Groundwater in the vicinity of the TSD is more than 20 mbgl (Deeper Broome Sandstone aquifer). Whilst there are areas of perched groundwater they are not connected to the Deeper Broome Sandstone aquifer. The decant pond will be maintained to a minimum and comprises of a floating pontoon. Water will be pumped directly to the processing plant.
		Rupture of pipeline causing tailings discharge to land or waters	Native vegetation associated or drainage lines associated with surface water or shallow groundwater	Direct discharge	Contamination of drainage lines, inhibiting vegetation growth and survival	Moderate	Possible	Medium	The Works Approval Holder has committed to manage pipelines with the following methods: • Pipelines will be HDPE with welded joints or compression fittings. The slurry pipelines will have flanges at approximately 60 m intervals. • Pipelines will be above ground and located within earthern bunds; • Sumps will be located at low points along the pipeline routes to contain any material which is leaked; • If required, some sections will be buried to prevent damage from vehicles or interference of surface drainage. All buried pipework will be signed; and • Tailings and return water pipelines will be inspected twice per shift. Conditions will be imposed on the Licence for management of pipelines.
		Overtopping/breach of containment causing discharge to land	Native vegetation associated or drainage lines associated with surface water or shallow groundwater	Direct discharge	Inundation of surrounding soils or contamination of drainage lines, inhibiting vegetation growth and survival	Moderate	Possible	Medium	At the end of deposition, it has been calculated a nominal operational pond of 1.0 m depth will result, with pond elevation being 1.0 m below the crest of the Cell 1 embankment, therefore complying with total freeboard of 0.5 m. Decant pond location, decant and return water system operation, seepage and integrity of embankment will be inspected twice per shift. Conditions to ensure operational freeboard of 0.5 m is maintained will be imposed on the Licence. Conditions to formalize the inspections will also be imposed on the Licence.

	Operation of load out facilities	Dust and spillage of product during loading	Human receptors: Mt Jowlaenga Station (8 km) Nillibubbica rest stop (27 km) Kimberly Meat Co. (28 km) Bidan Aboriginal Community (28 km) Yeeda Outstation (28 km)	Air/wind dispersal	Health and amenity impacts	N/A	N/A	N/A	Product will be stored, either bagged or in bulk, within enclosed sheds. Premium zircon and HiTi-88 is packaged into 2 tonne FIBC bulk-bags on the Premises, within a bagging facility on a continuous basis as the product becomes available. It will then be stored within the baggage storage shed until collection. Forklifts will load bags onto the road trains from both sides whilst the full road train is parked inside the storage shed to ensure bags are kept dry and dust and spillage are contained. Bulk products (titano-magnetite, zircon concentrate, LTR ilmenite and ilmenite) will be stored in enclosed segregated sheds whilst waiting for collection by purpose-designed quad-trailer road trains. Front-end loaders will be used to load the product into the trailers whilst inside the storage shed. The shed will have trafficable concrete floors and retaining walls to enable clean-up and minimize dust. Given the remoteness of the site and the management methods in place by the Works Approval Holder, the delegated officer considers the risk from potential dust and spillage from the load out facilities to be negligible.

Decision

The Delegated Officer has assessed the risks associated with construction and operation of the initial above-ground TSF and the product load out facilities and has deemed they are acceptable with some additional regulatory controls.

Works Approval Holder controls for the construction of the works are conditioned on the Works Approval to ensure that the initial above-ground TSF is constructed as per design specifications. The Delegated Officer has determined that whilst this Works Approval details the options for the in-pit TSF configuration, only the initial TSF is permitted to be constructed. The Works Approval Holder will need to confirm with DWER which option will be progressed and at which point the Works Approval can be amended to reflect this.

Conditions within the Works Approval have been updated to include infrastructure requirements for the initial TSF.

A condition requiring the submission of the TSF Operations Manual along with the proposed locations of the bores will be required prior to the operation of the initial TSF.

Works Approval Holder's comments

The Works Approval Holder was provided with the draft Amendment Notice on 19 March 2019. Comments received from the Works Approval Holder have been considered by the Delegated Officer as shown in Appendix 2.

Amendment

1. Condition 3 of the Works Approval is amended by the deletion of the text shown in strikethrough below and the insertion of the red text shown in underline below:

   Subject to Condition 2, within 28 days of the completion of the Works specified in Column 1 of Table 1 for each of Phase 2, ~~3/4~~ 3/4 and 5, the Works Approval Holder must provide to the CEO a report from a ~~suitably qualified professional~~ suitably qualified Professional Engineer confirming each item of infrastructure or component of infrastructure specified in Column 1 of Table 1 below has been constructed with no material defects and to the requirements specified in Column 2.

2. The Works Approval is amended by the insertion of condition 4A, following condition 4 and preceding condition 5, as shown in red underline below:

   4A. The Works Approval Holder shall commission the:
   - *Initial TSF for a period of no longer than 16 weeks;*
   - *Process plant (WCP1 and MSP1) and TSF for a period of no longer than 16 weeks; and*
   - *Process plant (WCP2 and MSP2) for a period of no longer than 16 weeks following submission of the report required by Condition 3.*

3. Table 1 of the Works Approval is amended by the insertion of the red text shown in italics and deletion of text shown in strikethrough below:

Table 1: Infrastructure and equipment requirements table

Column 1	Column 2	Column 3
Infrastructure/ Equipment	**Requirements (design and construction)**	**Site plan reference**
Phase 2 – Construction of sewage treatment plants, landfill, pre-production mining		
Sewage treatment plants	Constructed in accordance with drawings 6000-STD-01-001, STD-DWG-100, 180301-01 and 180301-02, as per the memo dated 23 April 2018 submitted as an addendum to the Application by MBS Environmental on 23/04/2018	"Sewage treatment plan", as shown in the map in Schedule 1
Landfill	First cell to be constructed no greater than 30 x 10 x 4 metres, within the specified landfill area (200 x 400 m) Cell to be surrounded by a 1 m high earthen bund, to prevent surface water runoff from entering	"Landfill", as shown in the map in Schedule 1
Phase 3 – Construction of TSF		
Initial above ground tailings storage facility	*Constructed in accordance with drawings 113094.05_04 to 15 as detailed in the TSF Design Report dated January 2019, authored by ATC Williams –submitted 10 January 2019*	*TSF as shown in Schedule 1*
Groundwater monitoring bores	*Must install at least five monitoring bores in the vicinity of the above ground TSF, including one, at a suitable location up-gradient of the facility, to monitor background groundwater quality. Bores must be:* • *Sited in accordance with WQPN #30 ('Siting of monitoring bores' section);* • *Of the four bores to monitor groundwater flow and contaminant transfer, there should be one located at each end of the facility, and one located on each side of the facility.* • *Installed to meet requirements of the Minimum Construction Requirements for Water Bores in Australia;*	*Not specified*
Stormwater Storage Pond	*Constructed to capture surface water runoff from the TSF in accordance with drawings 113094.05_04 to 15 as detailed in the TSF Design Report dated January 2019, authored by ATC Williams – submitted 10 January 2019*	*SSP as shown in Schedule 1*
Return water pipelines	*Constructed with:* *a) provided with secondary containment sufficient to contain any spill for a period equal to the time between routine inspections; or* *b) equipped with telemetry systems and pressure sensors along pipelines to allow for the detection of leaks and failures; and* *c) equipped with remotely controlled cut-outs in the event of a pipe failure.*	*Not specified*
Phase ~~3~~/4 4/5 – Construction of WCP1/MSP1 & WCP2/MSP2		

Column 1	Column 2	Column 3
Infrastructure/ Equipment	**Requirements (design and construction)**	**Site plan reference**
WCP	Constructed in accordance with PFD drawings 1306-G-PF-000-0111 to 1306-G-PF-000-0113	"WCP1" & "WCP2", as shown in the map in Schedule 1
MSP – Zircon Separation Plant	Constructed in accordance with PFD drawings 1306-G-PF-000-0116 and 0117	"MSP1" & "MSP2", as shown in the map in Schedule 1
MSP – Wet Zircon Plant	Constructed in accordance with PFD drawing 1306-G-PF-000-0118	
MSP – Dry Zircon Plant	Constructed in accordance with PFD drawing 1306-G-PF-000-0119	
MSP – Ilmenite Dry Plant	Constructed in accordance with PFD drawing 1306-G-PF-000-0122	
MSP – Low Temperature Roast	Constructed in accordance with BFS PFD drawing H351137-2350-210-280-0003 and Hatch description document H351137-0000-210-242-0001	
MSP – Ilmenite Magnetic Separation Plant	Constructed in accordance with PFD drawing 1306-G-PF-000-0132	
Hot Acid Leaching Plant	Constructed in accordance with PFD drawings 1306-G-PF-000-0114 and 0115	
Acid Storage and Handling Plant	Constructed in accordance with PFD drawing 1306-G-PF-000-0125	Not specified
Caustic Storage and Handling Plant		
Lime Storage and Handling Plant		
Process water supply system	Constructed in accordance with PFD drawings 1306-G-PF-000-0123 and 0124	
Non-magnetic stockpiles	Constructed in accordance with PFD drawing 1306-G-PF-000-0121	
Central Storage and Transfer Pond	Lined to achieve a permeability of at least $1x10^{-9}$ m/s	
WCP Process Water Pond		
WCP Settling Ponds		

Column 1	Column 2	Column 3
Infrastructure/ Equipment	**Requirements (design and construction)**	**Site plan reference**
Return water and *tailings* ~~mining~~ pipelines	~~Constructed with:~~ ~~(a) automatic cut-outs in the event of pipe failure; or~~ ~~(b) secondary containment sufficient to contain any spill for a period equal to the time between routine inspections; or~~ ~~(c) telemetry systems and pressure sensors along pipelines to allow the detection of leaks and failures~~ *Constructed with:* *a) secondary containment sufficient to contain any spill for a period equal to the time between routine inspections; or* *b) equipped with telemetry systems and pressure sensors along pipelines to allow for the detection of leaks and failures; and* *c) equipped with remotely controlled cut-outs in the event of a pipe failure.*	
WCP drain	Constructed to capture surface water runoff from WCP areas with water directed to sumps with sufficient capacity to contain an extreme rainfall event	
MSP drain	Constructed to capture surface water runoff from MSP areas (including product stockpiles) with water directed to sumps with sufficient capacity to contain an extreme rainfall event	
Pit bund	Constructed around the edge of the active mining pit, with the location moving as the active mining area changes over time	

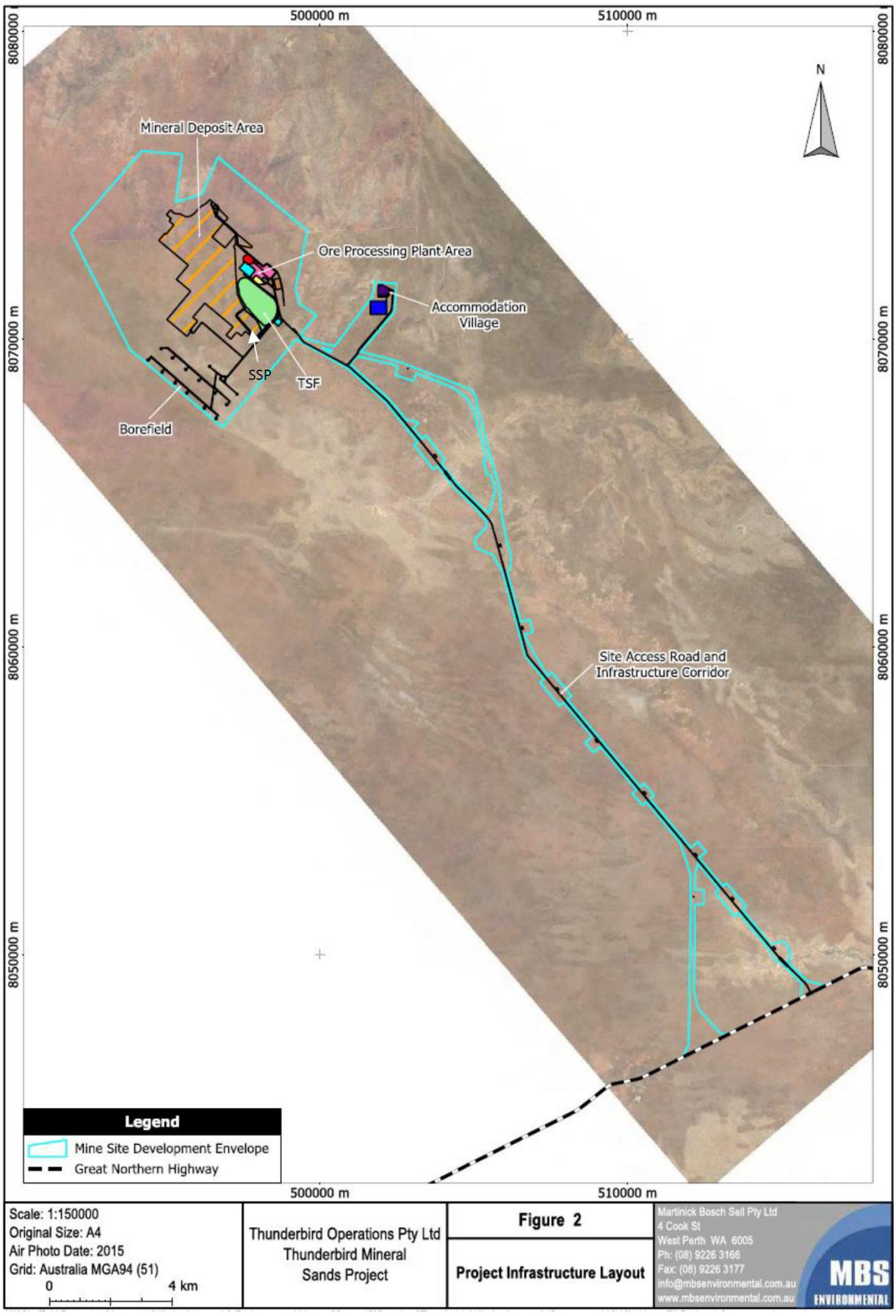
4. Table 2 of the Works Approval is amended by the insertion of the red text shown in italics below:

Table 2: Authorised Emissions table

Column 1	Column 2
Emission type	**Exclusions/Limitations/Requirements**
Specified Emissions	
Discharge of treated sewage	• Only during Commissioning • Only to the “Irrigation Spray Field”, as shown in the map in Schedule 1
Discharge of tailings	• *Only during Commissioning* • *Only to the initial TSF, as shown in the map in Schedule 1*
General Emissions	
Emissions which arise from undertaking the Works	Emissions excluded from General Emissions are: • Unreasonable Emissions; or • Emissions that result in, or are likely to result in, Pollution, Material Environmental Harm or Serious Environmental Harm; or • Discharges of Waste in circumstances likely to cause Pollution; or

Column 1	Column 2
Emission type	**Exclusions/Limitations/Requirements**
	• Emissions that result, or are likely to result in, the Discharge or abandonment of Waste in water to which the public has access; or • Emissions or Discharges which do not comply with an Approved Policy, a prescribed standard, or the conditions in an Implementation Agreement or Decision; or • Emissions or Discharges the subject of offences under regulations prescribed under the EP Act, including materials discharged under the *Environmental Protection (Unauthorised Discharges) Regulations 2004*.

5. Schedule 1 of the Works Approval is amended with the insertion of the following additional Premises map and Site plan reference:


500000 m
510000 m
8080000
8070000 m
8060000 m
8050000 m
N
Mineral Deposit Area
Ore Processing Plant Area
Accommodation Village
SSP
TSF
Borefield
Site Access Road and Infrastructure Corridor
Legend
Mine Site Development Envelope
Great Northern Highway
Scale: 1:150000
Original Size: A4
Air Photo Date: 2015
Grid: Australia MGA94 (51)
0
4 km
Thunderbird Operations Pty Ltd
Thunderbird Mineral Sands Project
Figure 2
Project Infrastructure Layout
Martinick Bosch Sell Pty Ltd
4 Cook St
West Perth WA 6005
Ph: (08) 9226 3166
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MBS ENVIRONMENTAL

6. Table 3 of Schedule 2 of the Works Approval is amended by the insertion of the below text shown in red italics:

Table 3: Authorised Works

Works
Civil excavation and earthworks, including clearing of vegetation
Road construction
Construction of WCP and MSP and associated infrastructure for Phases 3/4, including process water ponds/settling ponds and associated pipelines
Construction and commissioning of the initial TSF and associated infrastructure including the SSP, associated pipeline and monitoring bores
Stripping of topsoil and stockpiling
Overburden removal and development of the initial mine 'start pit'
Construction and commissioning of the sewage treatment plants
Establishment of first landfill trench, ex-borrow pit

Appendix 1: Key documents

	Document title	In text ref	Availability
1	Works Approval W6088/2017/1 – Thunderbird Operations Pty Ltd	W6088/2017/1	accessed at www.dwer.wa.gov.au
2	Thunderbird Mineral Sands Project, Works Approval Amendment Application W6088/2017/1, Prepared for Thunderbird Operations Pty Ltd by MBS Environmental, September 2018	Application	DWER records (A1723958)
3	Thunderbird Mineral Sands Western Australia Tailings Storage Facilities Design Report, ATC Williams, January 2019, 113094.05 R01 Rev 4	Williams 2019	DWER records (A1755254)
3	DER, July 2015. *Guidance Statement: Regulatory principles.* Department of Environment Regulation, Perth.	DER 2015a	accessed at www.dwer.wa.gov.au
4	DER, October 2015. *Guidance Statement: Setting conditions.* Department of Environment Regulation, Perth.	DER 2015b	
5	DER, November 2016. *Guidance Statement: Risk Assessments*. Department of Environment Regulation, Perth.	DER 2016b	
6	DER, November 2016. *Guidance Statement: Decision Making*. Department of Environment Regulation, Perth.	DER 2016c	

Appendix 2: Summary of Licence Holder comments

The Works Approval Holder was provided with the draft Amendment Notice on 19 March 2019 for review and comment. The Works Approval Holder responded on 3 April 2019. The following comments were received on the draft Amendment Notice.

Summary of Licence Holder comment	DWER response
Question 1 *– The works approval holder is to confirm the type of flocculant to be used, identify any ecotoxicological hazards present and their bioavailability.* **Answer:** The proposed flocculant is Magnafloc 155 (BASF), a high molecular weight anionic polyacrylamide (PAA) that is widely used in mineral processing and water treatment. I have attached the Technical Information and Safety Data Sheet for this product. The polymer based on its structural properties is not biologically available and accumulation in organisms is not to be expected. PAA is composed of carbon, hydrogen, oxygen and nitrogen and does contain other elements such as phosphorus and sulphur often found in other surface active substances PAA degrades slowly in the environment, although it is not classified as readily biodegradable by OECD criteria. It is unlikely to result in oxygen depletion of surface and groundwaters. PAA is not particularly toxic to aquatic organisms: LC50 concentrations for fish (*Oncorhynchus mykiss*, 96 hr) and *Daphnia magna* (48 hr) are > 100 mg/L. PAA dose rate concentrations of process water prior to flocculation and adsorption to clays is in the range of 250 to 1,000 mg/L. It is not expected to migrate from mineral sand process tailings through 20+ metres of soil/regolith to groundwater at any concentrations approaching aquatic toxicity due to strong adsorption to process tailings, humic substances and clay minerals.	This information has been used to complete the risk assessment on the toxicological impacts from the supernatant pond to wildlife (mostly birds).

Summary of Licence Holder comment	DWER response
PAA has been approved by the NH&MRC since 1977 as a chemical recommended for use in the treatment of drinking water (Table 8.2, Australian Drinking Guidelines 6 2011, Updated 2016.)	
Question 2 *– The works approval holder is to confirm that the current TSF design has been approved by DMIRS.* **Answer** – The TSF design is currently under assessment by DMIRS (RegID 76994).	Mining Proposal RegID 76994 was approved on 13 September 2019..
Question 3 *– Applicant to provide further clarification as to how drying and consolidation of tailings will be achieved given the extreme rainfall during the wet season in this region.* **Answer** - The Thunderbird TSF has been designed to allow runoff from the tailings stack to be collected at the toe of the beach and flow via gravity to form a decant pond at the low point of the tailings impoundment area. This water will then flow into a concrete decant collection sump which will transfer the water via gravity drainage pipes to a HDPE lined recovery pond in the SSP. Since water is not stored on the tailings surface except for a minimal operating pond required to spill into the decant system without scouring out tailings, and as the sandy tailings material will be relatively well drained, the upper part of the tailings surface is not expected to be saturated. Excess rainfall resulting from cyclones and large rainfall events will run off the tailings surface to the decant area. Infiltrating water is envisaged to penetrate the surface at a maximum rate of less than 4 mm/hour. During the operational stage, tailings with an estimated saturated permeability of approximately 1 x 10^{-6} m/s will be exposed at the surface. In empirical terms, for unit surface area and unit hydraulic gradient, if the tailings were fully saturated, they would be able to absorb infiltration effectively. In the unsaturated state, effective permeability will be lower due to generation of pore suction, so less infiltration would occur and the tailings would remain	This information has been included in the risk assessment regarding seepage from tailings.

Summary of Licence Holder comment	DWER response
unsaturated. In summary rainfall on the sloping tailings beach does not have the capacity to saturate the tailings to any significant depth. The risk of significant remobilisation of tailings during cyclones or large rain events is considered low and containment provision for such events are effectively incorporated in the design.	
Question 4 *– Mining approval – comment for works approval holder – Is this now granted?* Answer – The current Mining Proposal (RegID 76994) which includes the TSF was recently re-submitted to DMIRS addressing several comments from their first review.	Mining Proposal RegID 76994 was approved on 13 September 2019.
Question 5 *– The Fraser river is located approximately 7 km north of the premises with tributaries that extend down to the north of the premises. Applicant to clarify how close these tributaries come to the premises and to the TSF and pipelines?* Answer – The tributaries enter the mining tenement boundary to the north however are more than 1.5 km from the TSF and/or pipelines. In addition there is a catchment divide between these tributaries and the project TSF. As can be seen below the TSF and pipelines are located within the Fraser River South Catchment whilst the tributaries end within the Fraser River Catchment. (Figure provided).	This information has been included in Table 7 under Major Waterbodies and Watercourses.
Question 6 *– The depth to groundwater is in excess of 20 m over most of the premises. Works Approval holder to advise if 20 mbgl is the shallowest groundwater gets?* Answer – The depth to groundwater in the Broome Aquifer is 20 or more than 20 mbgl across the site.	This information has been included in the Hydrogeology section of this report.
Question 7 *– Applicant to provide further information regarding tailings*	This information has been included in the risk assessment

Summary of Licence Holder comment	DWER response
performance given extreme rainfall conditions in wet season. Answer – See answer to question 3.	regarding seepage from tailings.
***Question 8** – Applicant to provide further justification on the number of monitoring bores. TSF will be 4 km long – will three monitoring bores be adequate?* Answer – The TSF perimeter embankment (circumference) is 4 km long and not the TSF itself. Combined with evaporative drying, the anticipated steep tailings beaches, rapid release of bleed water and rapid consolidation of tailings are expected to efficiently remove water from the tailings deposit such that the potential for tailings leachate seepage is minimised. The Thunderbird TSF has been designed to allow runoff from the tailings stack to be collected at the toe of the beach and flow via gravity to form a decant pond at the low point of the tailings impoundment area. This water will then flow into a concrete decant collection sump which will transfer the water via gravity drainage pipes to a HDPE lined recovery pond in the SSP. A minimal operational pond of 400 mm depth will be maintained behind the TSF/SSP dividing bund. The potential for seepage from this pond will be reduced by compacting the base of the TSF impoundment using a high impact roller. Based on the design intent (to remove water rapidly), and the short operational life of the facility (3 years), three monitoring bores is considered sufficient for the size of the TSF.	DWER has provided this information to an internal hydrogeologist for assessment who has determined that a minimum of five monitoring bores will be required for the TSF. The assessment table outlines the justification and a Works Approval condition has been added in Table 1 to formalize this requirement.
Error in draft document: On page 7 2nd para, referring to co-disposal tailings stream pumped to the in-pit void at **38%** solids. This is incorrect and will be the same as the initial TSF i.e. **49.9% solids**.	Noted and error corrected.
Amendment 1 states that a suitably qualified **geotechnical** engineer needs to confirm that each item of infrastructure or component of infrastructure specified in Column 1 of Table 1 has been constructed with no material	Noted. The condition will be re-worded to specify that a suitably qualified Professional Engineer must confirm the construction of the infrastructure. The term Professional Engineer will be

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defects. We can understand this could be required for the TSF and potentially the processing plant however question why a geotechnical engineer would need to sign off on the landfill and WWTP	defined.
Amendment 5 (new condition 8) – Thunderbird questions the requirement and validity of this condition. Groundwater monitoring is already required under the GLOS associated with the Groundwater licence issued for the project and Ministerial Statement 1080 (Condition 8) both of which are reported on to DWER annually. It is assumed that the initial assumption that the TSF was 4 km long triggered the need for this condition, however as stated above, the circumference of the TSF embankments are what measures 4 km and not the TSF itself. The current TSF report already contains a map with the location of the proposed bores and it is understood that the frequency of monitoring is normally determined under the Environmental Protection Act Licencing Process. Based on the above Thunderbird request that this condition not be add	Noted. Condition 8 was a requirement for the Works Approval Holder to submit a Groundwater Management Plan prior to operation. The intent of this condition was in association with the operation of the TSF. Given DWER's further assessment of monitoring bores for the facility (discussed above in Question 8), a requirement for the Works Approval Holder to install a minimum of five monitoring bores with specifications has been included in the Infrastructure and Equipment Requirement Table 1.