Government of Western Australia
Department of Water and Environmental Regulation

Decision Report

Application for Works Approval

Division 3, Part V *Environmental Protection Act 1986*

Works Approval Number	W6209/2019/1
Applicant	Hastings Technology Metals Limited
ACN	122 911 399
File Number	DER2019/000040
Premises	Yangibana Rare Earths Project
	Legal description - Mining Tenements G09/14, M09/158, M09/157, G09/16, G09/18, G09/17 and M09/161 WEST LYONS RIVER WA 6705
Date of Report	17/06/2020
Status of Report	Final

Table of Contents

List of Tables

List of Figures

1. Definitions of terms and acronyms

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

Table 1: Definitions

Term	Definition
ABK	Acid Bake Kiln
ACN	Australian Company Number
ADWG	Australian Drinking Water Guidelines
AEP	Annual Exceedance Probability
ANCOLD	Australian National Committee on Large Dams
ANSTO	Australian Nuclear Science and Technology Organisation
Applicant	Hastings Technology Metals Limited
ASLP	Australian Standard Leaching Procedure
Bq/g	Becquerels per gram
Category/ Categories/ Cat.	Categories of Prescribed Premises as set out in Schedule 1 of the EP Regulations
CEMS	Continuous Emissions Monitoring System
Decision Report	refers to this document.
Delegated Officer	an officer under section 20 of the EP Act.
Department	means the department established under section 35 of the *Public Sector Management Act 1994* and designated as responsible for the administration of Part V, Division 3 of the EP Act.
DMIRS	Department of Mines, Industry Regulation and Safety, Western Australian
DWER	Department of Water and Environmental Regulation As of 1 July 2017, the Department of Environment Regulation (DER), the Office of the Environmental Protection Authority (OEPA) and the Department of Water (DoW) amalgamated to form the Department of Water and Environmental Regulation (DWER). DWER was established under section 35 of the *Public Sector Management Act 1994* and is responsible for the administration of the *Environmental Protection Act 1986* along with other legislation.
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)
GCL	Geosynthetic composite liner
kW	Kilowatt
LEAF	refers to the US EPA Leaching Environmental Assessment Framework
LNG	Liquefied natural gas
LWCWD	Landfill Waste Classification and Waste Definitions
Minister	the Minister responsible for the EP Act and associated regulations
MREC	Mixed rare earth carbonate

MS	Ministerial Statement
MW	Megawatt
NAF	Non acid forming
NEPM	National Environmental Protection Measure
Noise Regulations	*Environmental Protection (Noise) Regulations 1997* (WA)
NORM	Naturally occurring radioactive material
PEC	Priority ecological community
PMF	Probable maximum flood
Prescribed Premises	has the same meaning given to that term under the EP Act.
Premises	refers to the premises to which this Decision Report applies, as specified at the front of this Decision Report
Primary Activities	as defined in Schedule 2 of the Works Approval
REE	Rare earths elements
Risk Event	As described in *Guidance Statement: Risk Assessment*
SAP	Sulfuric acid plant
TPA	Tonnes per annum
TSF	Tailings storage facility
$\mu g/m^3$	Micrograms per cubic metre
WESP	Wet Electrostatic Precipitator

2. Purpose and scope of assessment

Hastings Technology Metals Limited (Applicant) lodged an application for a works approval under Part V of the *Environmental Protection Act 1986* (EP Act) on 11 December 2018 to establish a rare earths elements (REE) ore processing facility (Rare Earths Facility) on mining tenements on Wanna Station and Gifford Station, approximately 150 km northeast of Gascoyne Junction in the Shire of Upper Gascoyne. The 11 December 2018 works approval application was superseded by revised supporting documentation received by the Department of Water and Environmental Regulation (DWER) from the Applicant on 10 June 2019 and 24 June 2019 (the Application).

The Rare Earths Facility forms part of the broader ten year life of mine Yangibana Rare Earths Project (Yangibana Project) which will include nearby REE ore mining operations. In addition to an ore processing plant, the Rare Earths Facility will include two tailings storage facilities (TSFs) and other waste management and ancillary supporting infrastructure. The processing plant will process up to 1.1 million tonnes per annum (Mtpa) of the REE ore obtained from nearby pits at Fraser's, Bald Hill and Yangibana.

This Decision Report documents the assessment and determination of the Application consistent with DWER's Regulatory Framework. The scope of risk assessment includes potential impacts from emissions and discharges during the construction, commissioning and operational phases of the Rare Earths Facility.

A mobile crushing and screening plant, putrescible landfill and sewage treatment facility for preliminary investigative and exploratory activities associated with the Yangibana Project is already subject to Works Approval W6158/2018/1, and therefore are not within the scope of this assessment.

REE ore mining activities in nearby pits at Fraser's, Bald Hill and Yangibana are not within the scope of this assessment as the extractive mining activities (with the exception of a proposed mine dewater discharge) are not within the regulatory capture of Part V of the EP Act. The

Yangibana Rare Earths Project, including mine pits, is subject to Ministerial Statement 1110 under Part IV of the EP Act.

The application details a proposed sulfuric acid plant (SAP), however the Applicant notified DWER on 15 January 2020 that it had opted to defer this while further investigations are undertaken on emissions and potential impact mitigation measures. The proposed SAP is therefore not within the scope of this assessment. It is understood the Applicant will submit a separate application for the SAP at a later date.

2.1 Application details

Table 2 lists the documents submitted during the assessment process.

Table 2: Documents and information submitted during the assessment process

Document/information description	Date received
Application form, Works Approval under Part V, Division 3, *Environmental Protection Act 1986*, including the following supporting documents and attachments: • Attachment 1A – Mining tenement summary reports • Attachment 1B – ASIC company extract • Attachment 1C – Applicant letter of authority • Attachment 2 – Maps depicting site location, layout, emission points and environmental receptors • Attachment 3A – Technical description Cogen unit • Attachment 7 – Siting and location • Attachment 8 – Project-wide: Works Application, supplementary documentation (including Appendices A to I); • Digital shapefiles for mapping of emission points, premises footprint and the boundary tenure *Note: The documentation listed above was superseded by revised supporting documentation lodged by the Applicant on 10/06/2019 and 24/06/2019 as listed below.*	11/12/2018
Applicant response to DWER request for further supporting information and copies of plume study modelling input files	12/04/2019
Applicant revised application for works approval and supporting documentation – key changes to supporting documentation relates to the altered proposed TSF configuration.	10/06/2019
Applicant corrected version of Attachment 8 and appendices, superseding the version of Attachment 8 and appendices lodged on 10/06/2019.	24/06/2019

Applicant submission addressing:
• Review of the plume model
• Inventory of emissions from the Acid Bake Kiln
• Details of proposed Continuous Emissions Monitoring System (CEMS)
• Further information on category 73 bulk storage chemicals and spill management/ contaminated stormwater controls
    ○ Appendix A ERM (2019) Yangibana Rare Earths Project, Review of the Plume Model, October 2019
    ○ Appendix B Hastings (2019) Surface Water Management Plan, September 2019
	5/12/2019

Document/information description	Date received
Applicant request to defer the sulfuric acid plant and further information on air emissions modelling.	15/01/2020

The Applicant has applied for the prescribed premises categories and production or design capacities listed in Table 3.

Table 3: Prescribed Premises Categories in the Application

Classification of Premises	Description	Approved Premises production or design capacity or throughput
Category 5	Processing or beneficiation of metallic or non-metallic ore: premises on which — (a) metallic or non-metallic ore is crushed, ground, milled or otherwise processed; or (b) tailings from metallic or non-metallic ore are reprocessed; or (c) tailings or residue from metallic or non-metallic ore are discharged into a containment cell or dam.	1.1 million tonnes per annum
Category 6	Mine dewatering: premises on which water is extracted and discharged into the environment to allow mining of ore	60,000 tonnes per annum
Category 52	Electrical power generation: premises (other than premises within category 53 or an emergency or standby power generating plant) on which electrical power is generated using a fuel.	20.16 MW per annum
Category 64	Class II or III putrescible landfill site: premises (other than clean fill premises) on which waste of a type permitted for disposal for this category of prescribed premises, in accordance with the Landfill Waste Classification and Waste Definitions 1996, is accepted for burial.	3,487 tonnes per annum
Category 73	Bulk storage of chemicals etc.: premises on which acids, alkalis or chemicals that – (a) contain at least one carbon to carbon bond; and (b) are liquid at STP (standard temperature and pressure), are stored.	1,255 m^3 in aggregate
Category 85	Sewage facility: premises – (a) on which sewage is treated (excluding septic tanks); or (b) from which treated sewage is discharged onto land or into waters.	34 m^3/day

3. Background

The Applicant is an ASIC listed company and holds the tenements for the premises under its fully owned subsidiaries, Gascoyne Metals Pty Limited and Yangibana Pty Ltd. The underlying land tenure for the Rare Earths Facility is pastoral lease overlying Gifford Creek Station and Wanna Station which are both owned by the same leaseholder.

The Rare Earths Facility will be located on the following Mining Tenements:

- REE ore processing plant on G09/14;
- TSFs (1/2 and 3) on G09/16,
- pit dewatering discharges within M09/157 and M09/158, and
- the landfill is located within G09/18, M09/158, G09/17, M09/157, and M09/161.

The Rare Earths Facility is approximately 370 km east-northeast of the town of Carnarvon and approximately 150 km northeast of Gascoyne Junction, in the Shire of Upper Gascoyne as shown in Figure 1 below. The nearest dwelling is Gifford Creek Homestead approximately 15 km south-south-west of the proposed ore processing plant.

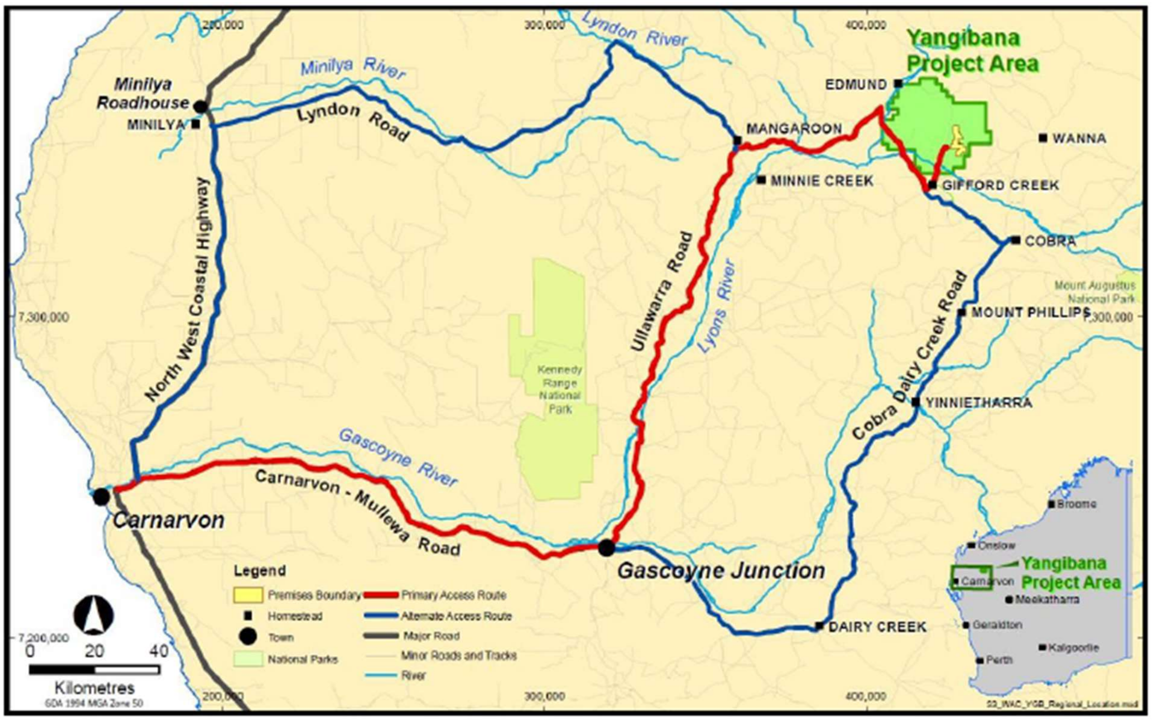


Figure 1: Yangibana Project regional location map (Source: the Application)

The Applicant has commenced early works activities associated with site investigations and exploration, including an installation and use of an accommodation village to which an existing Works Approval W6158/2018/1 (mobile crushing and screening plant, landfill and sewage treatment plant) under Part V of the EP Act applies. These early works were also authorised under Part IV of the EP Act via a s41A(3) approval.

The Yangibana Project will include mining of REEs, both above and below the water table from four mining pits at Bald Hill, Yangibana and Fraser's which are located in proximity to the Rare Earths Facility. The ore bodies will be mined using conventional open cut pit methods of drill and blast, load and haul. Mining activities, including the management of waste rock generated through mining are not prescribed activities and therefore not subject of assessment in this Decision Report.

REE ore will be trucked to the Run of Mine (ROM) pad at the Rare Earths Facility where it will be concentrated into a mixed rare earth carbonate (MREC) rich in neodymium (Nd) and Praeseodymium (Pr) for transport to port for overseas export. The Nd and Pr within the MREC product are key materials of permanent magnets used in components of new technologies such as electric vehicles, renewable energy, wind turbines and electrical consumer products.

4. Overview of Premises

4.1 Infrastructure

The Yangibana Project infrastructure, as it relates to Category 5, 6, 52, 64, 73 and 85 activities, is detailed in

Table 4 which lists infrastructure associated with each prescribed premises category. Premises layout maps are provided in Appendix 2 including:

- Premises general layout plan;
- Ore processing plant general layout plan; and
- TSF site layout plan

Table 4: Yangibana Project Category 6, 6, 52, 64, 73 and 85 infrastructure

	Infrastructure	Site Plan Reference in Appendix 2
Prescribed Activity Category 5		
Processing and concentrating up to 1.1 Mtpa of REE to produce a MREC for export. Processing steps include crushing, screening and grinding, acid baking in a kiln and concentration through the ore processing plant that includes a Beneficiation Plant and Hydrometallurgical Plant. Tailings generated from the plants are stored in the respective Beneficiation TSF and Hydromet TSF.		
Beneficiation Plant		
1	Key components including: • ROM pad • Ore crushers, screeners and grinders • Flotation cells, conditioning tanks, thickeners and filters • Gas-fired concentrate drier	Premises general layout map; Ore processing plant general layout map
Hydrometallurgical Plant		
2	Key components including: • Acid bake rotary kiln • Acid bake kiln off-gas treatment unit • Water leaching equipment including tanks, vessels, thickeners, filters water leaching, impurity removal, uranium removal, precipitation and effluent treatment • Product bagging and packaging infrastructure	Premises general layout map; Ore processing plant general layout map
Beneficiation TSF		
3	• Paddock style facility with perimeter discharge via spigots with 11 m maximum embankment height, with decant pond, decant tower • Tailings delivery and return water pipelines.	Premises general layout map; TSF general layout map
Hydromet TSF		
4	• Paddock style facility and single point discharge 36 ha Hydromet TSF • Geo-composite liner (composite clay overlain with HDPE liner) • Underdrainage collection pipe installed on top of HDPE liner in the valley of the TSF	Premises general layout map; TSF general layout map

	Infrastructure	Site Plan Reference in Appendix 2
	• Tailings delivery line.	
Prescribed Activity Category 6		
Discharge of excess Frasers Pit and Bald Hill Pit dewater from respective turkey nests to a localised drainage line during a modelled worst-case operating scenario (process plant shutdown coinciding with a 1:100 year ARI rainfall event).		
1	Bald Hill Pit Turkeys Nest and discharge point	Premises general layout map
2	Frasers Pit Turkeys Nest and discharge point	
Prescribed Activity Category 52		
A power station with gas reciprocating generator sets and a diesel black start generator. The maximum load will be 12.1 MW and the average load is 10.9 MW with an installed generation capacity of 20.16 MW.		
1	Six 3.36 MW gas reciprocating generator sets	Ore processing plant general layout map
2	One 800 kW diesel black start generator set	
3	Diesel Fuel storage tank	
Prescribed Activity Category 64		
Class II putrescible landfill bunker with 3,487 tpa putrescible and inert waste burial capacity and expected burial rate of approx. 3,170 tpa		
1	Approx. 1000m^2 waste depot	Ore processing plant general layout map
2	Frasers waste rock dump – putrescible waste bunker and inert waste bunker	Premises general layout map
3	Bald Hill waste rock dump - putrescible waste bunker and inert waste bunker	
Prescribed Activity Category 73		
Bulk storage of 1,255 m^3 of RE-60, Rinkalore F410 and diesel in aggregate.		
1	968 m^3 maximum capacity self-bunded diesel storage tank with refuelling bay connected to a drainage sediment pond	
2	267 m^3 maximum capacity RE-60 storage bladders on flatbed trucks upon an surface apron with a drive over kerb sloping back into the storage tank bund	
3	20 m^3 maximum capacity RInkalore F410 in IBCs within the storage tank bund	
Prescribed Activity Category 85		
A 34 m^3/day maximum capacity sewage treatment plant for the ore processing plant and mine support buildings. Treated wastewater discharged to a 1 ha sprayfield.		
1	Five stage Bardenpho activated sludge treatment plant	Premises general layout map
2	One hectare irrigation sprayfield	

4.2 Exclusions

The following activities are not related to prescribed categories and beyond the scope of this assessment:

- Mining of REE and waste rock disposal – regulated under Part IV of the *EP Act* and the *Mining Act 1978*;

- Abstraction of groundwater for mining, ore processing and potable water supply – groundwater abstraction is regulated under the EPBC Act, Part IV of the EP Act and *Rights In Water and Irrigation Act 1914*;
- Manufacture of concrete at the batching plant located within the premises – Category 77 only applies where the manufacture of concrete is for use on other premises;
- Bioremediation of hydrocarbon contaminated soils generated within the premises on a bioremediation pad; and
- Bulk storage of chemicals that do not fall within the definition of Category 73.

Clearing of native vegetation is authorised through MS 1110 granted under Part IV of the EP Act and therefore not considered in this assessment.

The geotechnical stability of the TSFs and related safety risks are regulated under the *Mines Safety and Inspection Act 1994* and associated regulations, by the Department of Mines, Safety and Industry Regulation (DMIRS) and hence these aspects are excluded from the works approval application assessment.

As noted in section 2, the Applicant has deferred the SAP therefore it has been excluded from the scope of works.

4.3 Construction overview

The construction phase will include civil earthworks and general construction and installation activities relating to the ore processing plant, TSFs, power plant, sewage facility, landfill/waste depot and other ancillary components.

4.4 Commissioning overview

The Application described and defined various types and stages of commissioning actions for broader infrastructure components of the prescribed activities. On review of the Application, the Delegated Officer identified commissioning stages and activities that may generate emissions and discharges and are therefore relevant to this assessment. These have been summarised in Table 5.

Table 5: Infrastructure commissioning stages and activities involving emissions and discharges (Source: Application)

Infrastructure	Applicant commissioning stage involving emissions / discharges	Commissioning activities
Processing plant	Load/ore commissioning	Plant is placed in service including the introduction of ore and feedstock. Plant is ramped to full production with performance testing.
TSFs	Tailings commissioning	Comprises test operation of equipment with tailings.
Mine dewatering	None	Commissioning activities involve verification of infrastructure and equipment and are not expected to result in the direct discharge of mine dewater to the environment.
Power plant	Dry commissioning	Progressive start up and operation of each power generation unit
	Emission testing	Emission testing at various load settings
	Last commissioning	Units undergo a full mapping exercise where they are tuned to demonstrate the emission limits comply based on the liquefied natural gas (LNG) and diesel supply
Landfills	None	Commissioning activities involve verification of design and construction specifications and do not involve deposition of waste.

Infrastructure	Applicant commissioning stage involving emissions / discharges	Commissioning activities
WWTP	Wet commissioning	Chlorine and bacteria loaded into appropriate tanks. Wet commissioning with effluent over a 3-month period with sampling, verification against limits, infrastructure checks spray field effectiveness.

4.5 Operational overview

4.5.1 Category 5 - ore processing

The Application describes the process as relatively simple, using industry standard unit processors. The process flow diagram provided in the Application is shown in Figure 2 and depicts the two stages or plants (Beneficiation Plant and Hydrometallurgical Plant) that make up the REE ore processing plant. The Application contained a more detailed description of the process steps, however only a brief summary of the key steps has been included in this Decision Report.

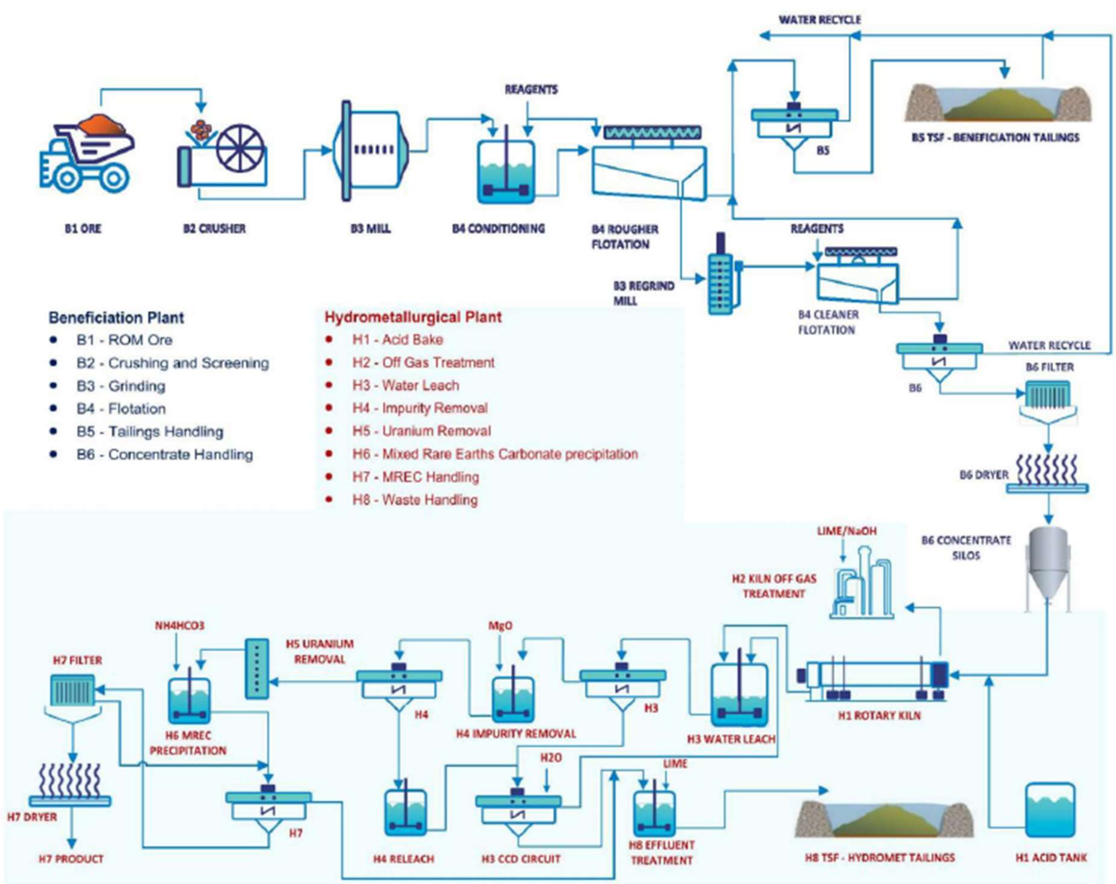


Figure 2: Process flow diagram (Source: Application)

Beneficiation Plant

REE ore stockpiled on the ROM pad is fed to the crusher feed bin to commence the process with the crushed product then ground in the semi-autogenous grinding (SAG) mill. The flotation process then occurs consisting of one rougher circuit, a regrind mill and four cleaner circuits.

The tailings stream from each stage of flotation, rougher and cleaners 1-4, are treated with lime in an agitated pre-treatment tank and then pumped to the flotation tailings thickener with a thickener underflow pumped to the Beneficiation TSF. A collected concentrate from the cleaner 4 flotation cells is thickened and filtered whereby a filter cake product undergoes moisture reduction in a gas fired dryer.

Concentrate is then transferred to the concentrate bins, which provide surge capacity between the beneficiation plant and the hydrometallurgical plant processes that follow.

Hydrometallurgical Plant

The filter cake concentrate from the beneficiation plant is mixed with dilute and 98% concentrated sulfuric acid and fed to the acid bake rotary kiln. The acidic concentrate is acid baked at 275°C to "crack" the monazite mineral and allow for rare earths to be recovered. Kiln off gas is treated by a gas scrubbing plant to recover 60% sulfuric acid and gases are further scrubbed with caustic soda.

The acid bake product is then directed to a series of agitated water leach tanks for thickening. A water leach thickener overflow is collected and pumped to the impurity removal circuit and an underflow slurry is pumped to effluent treatment.

Impurity removal involves neutralisation with magnesium oxide to raise the pH and precipitate impurities. A discharge flows to a thickener for solid liquid separation. Iron concentrations of the ore are variable and iron may also be removed by adding hydrogen peroxide prior to the first impurity circuit tank. A belt filter separates and washes solid portions and liquor. The filter cake solids are sent to the acid re-leach process.

The filter cake is leached of co-precipitated REEs using recovered dilute sulfuric acid. An impurity removal thickener overflow feeds liquor to uranium removal via a duty polishing filter, which removes any solids carried over from the thickener. REE containing liquor is then pumped to the REE carbonate precipitation feed tank with acidic waste liquor from the circuit pumped to the effluent treatment tank.

REE carbonate precipitation involves addition of ammonium bicarbonate solution to precipitate REEs. Overflow is thickened and transferred to either the Hydromet TSF or effluent treatment. An underflow slurry is filtered and a filter cake dried in the REE carbonate dryer.

The dried and resulting MREC product will then be packaged into bulka bags and loaded into shipping containers for truck transport to port.

The above-referenced effluent treatment circuit involves tanks for addition of calcium carbonate or lime to neutralise free acid. A treated effluent slurry is sent to the Hydromet TSF.

4.5.2 Category 5 – Tailings storage facilities

The initial application proposed three TSFs along with an evaporation pond, however the Applicant modified the plant layout and design to combine tailings streams from TSF 1 and TSF 2 into a single 'Beneficiation TSF' and also combine tailings from TSF 3 and liquor from the evaporation pond into a single 'Hydromet TSF.' A separate Return Water Pond for TSF 1 in the original design was removed, replaced by a decant pond within the Beneficiation TSF. A simplified process flow diagram showing the tailings and overall water balance is shown below in Figure 3 and indicative site layout in Figure 4.

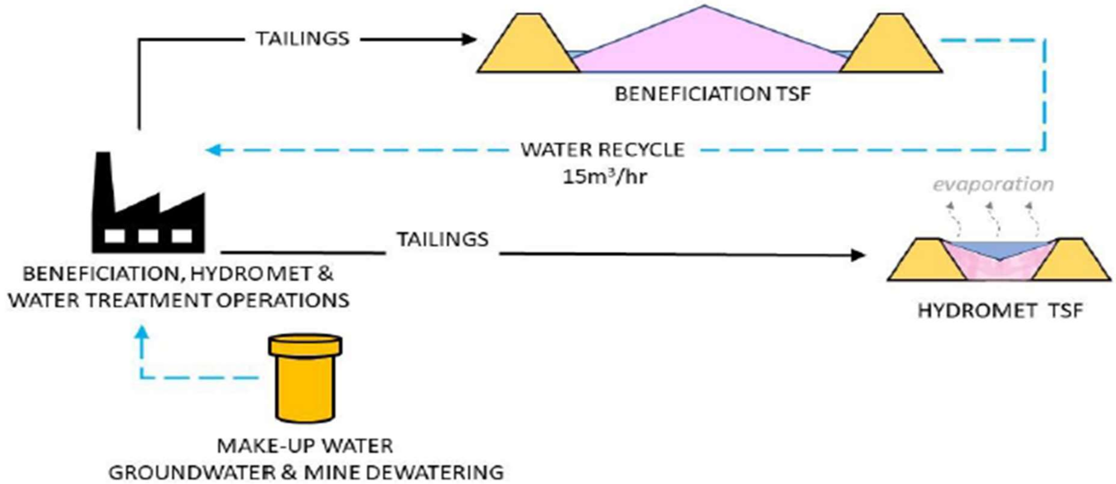


Figure 3: Tailings and liquor process diagram (Source: Application)

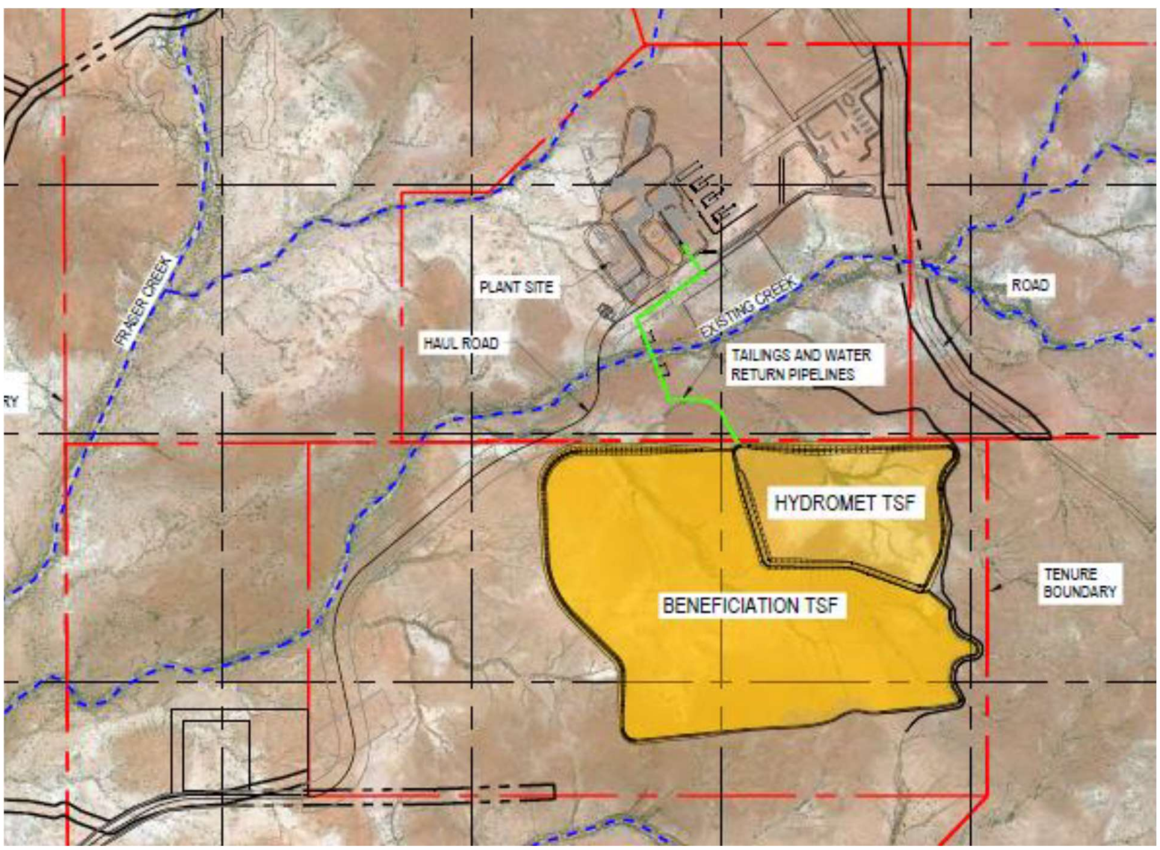


Figure 4: Indicative TSFs site layout (Source: Application)

The TSFs have been designed to store 10 Mt (plus 10% contingency) of tailings over a ten-year mine life. The Beneficiation TSF will receive a combined stream of coarse and finer tailings material by perimeter discharge with spigots. The Hydromet TSF will receive tailings from the Hydrometallurgical Plant and barren liquor (waste water from the hydrometallurgical process and reverse osmosis effluent from the water treatment plant) by a single point discharge. The Beneficiation TSF with its central decant pond and decant tower will receive tailings by perimeter discharge with spigots.

The TSFs have been designed to comply with DMIRS and ANCOLD guidelines which are further discussed in Section 8.

4.5.3 Category 6 – Mine dewatering discharge

Abstracted groundwater from dewatering Bald Hill Pit and Frasers Pit is to be directed to respective turkey's nests. During normal operating conditions, Applicant modelling shows all dewater will be utilised through dust suppression or reuse in the ore processing plant with no direct discharge required. However, under a conservatively modelled worst-case scenario, the turkeys nests will reach storage capacity and excess dewater will be discharged from the respective turkeys nest to the nearest drainage line. The modelled worst-case scenario relates to a scheduled or unscheduled plant shutdown coinciding with a 1:100 year average recurrence interval (ARI) rainfall event. The management of mine dewater is depicted in Figure 5 below, with the red boxes depicted the respecting discharges of Bald Hill Pit and Frasers Pit dewater during worst-case scenarios.

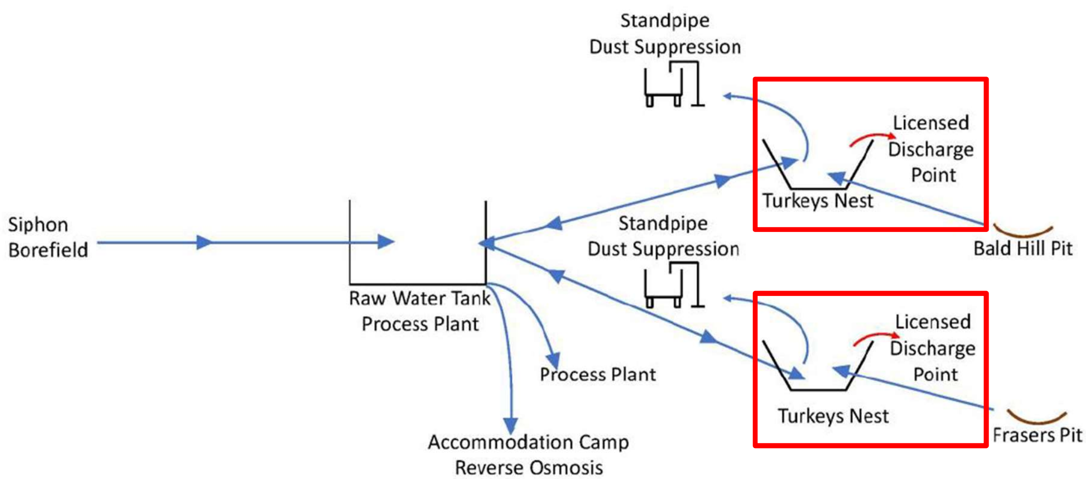


Figure 5: Mine dewater discharge flow diagram (Source: Application)

4.5.4 Category 52 – power generation

The power station housed within the ore processing plant area consists of six 3.36 MW gas reciprocating generator sets and one 800 kW diesel black start generator. The maximum load is expected to be 12.1 MW, the average load 10.9 MW with an installed generation capacity of 20.16 MW. The power station operates unattended with 24 hours fuel storage for the diesel black start generator and 1230 tonnes of LNG storage (20 days, 5 operational and 15 days wet weather).

4.5.5 Category 64 – landfilling

Waste will be sorted at a waste depot adjacent to the ore processing facility. Waste that is not recycled or reused will be buried in landfill bunkers located within Frasers and/or Bald Hill waste rock landforms. Waste burial rates are expected to be up to 670 tpa of putrescible waste and 2,500 tpa of inert waste (total of 3,170 tpa).

Two bunkers will be active at any one time; one for putrescible waste and another for inert waste. Bunkers are 50 m long, 10 m wide and 2 m deep with side batters sloped at 1:2 to provide stability. Putrescible waste is to be covered regularly by 300 mm of soil, with the inert bunker remaining uncovered, unless windblown waste is a risk.

New bunkers are formed once full with locations moving within the waste rock landforms to suit the current tipping locations of the mining fleet.

4.5.6 Category 73 – bulk storage of chemicals

The Applicant provided the category 73 bulk chemical storage volumes shown in Table 6.

Table 6: Category 73 chemical storage volumes (source: Application)

Chemical	Previous storage (m^3)	Updated storage (m^3)	Updated maximum storage (m^3)	Delivery format	Storage format
RE-60	201	243	267	30 t container bladder	Storage tank
Rinkalore F410	16	18	20	186 kg drum/intermediate bulk container (IBC)	Drum/IBCs
Diesel	268	880	968	30 t tanker	Storage tank
Total	485	1,141	1,255		

The self-bunded diesel tank and associated refueling bay will have spill grates connected to an adjacent drainage sediment pond. RE-60 will be in collector bladders in containers positioned on the back of flatbed trucks positioned on an apron that has a drive over kerb and slop into the storage tank bund. Bunded area spillage is pumped to the Effluent Treatment section of the ore processing plant. Rinkalore F410 is stored in the bunded reagent storage area on spill pallets.

4.5.7 Category 85 – sewage treatment and disposal

A wastewater treatment plant (WWTP) treats sewage from the ore processing plant and mine support buildings. The system is containerised five stage Bardenpho activated sludge treatment plant designed to treat effluent to Western Australian Class C standards.

Raw sewage gravity feeds from source and via a pump station is screened and gravity fed to a balance tank. Screened inorganic waste is dewatered and automatically disposed into a bin. The balance tank provides a controlled twice daily flow into anaerobic treatment (Primary tank 1) where sludge from the clarifier is introduced. The mixed influent flows to anoxic treatment (Primary tank 2) for de-nitrification under anoxic conditions. Aeration through the aeration tank then aims for oxidation of nutrients, reducing ammonia, biological oxygen demand (BOD), chemical oxygen demand (COD) etc. Clarification in the clarifier tank then allows suspended activated sludge to settle out and influent is dosed and mixed with poly aluminium chloride to bind particles. Clear supernatant passes through baffles into the chlorine contact tank and settled sludge is removed via a pump to return activated sludge to the anaerobic tank. Wasted sludge is pumped into the sludge thickening tank for thickening pending removal via truck.

Wastewater is then chlorinated and directed to an irrigation tank where it is either transferred to a Class A polishing unit or discharged via a meter to the spray field.

It is noted that a similar WWTP is already authorised to be constructed and commissioned at the accommodation village, under W6158/2018/1 (refer section 5.5.2).

5. Legislative context

5.1 Legislative context summary

Table 7 summarises approvals relevant to the assessment.

Table 7: Relevant approvals and tenure

Legislation	Number	Subsidiary	Approval
Environment Protection and Biodiversity Conservation Act 1999 (Cth)	EPBC2016/7845	Hastings Technology Metals Limited	Matters of National Environmental Significance – Nuclear Action
Land Administration Act 1997	General Lease		Access to land within Gifford Creek and Wanna Stations.

Legislation	Number	Subsidiary	Approval
Rights in Water and Irrigation Act 1914	GWL183285(2)	Hastings Technology Metals Limited	Groundwater abstraction up to 0.28 GL per annum Ann additional groundwater abstraction licence to be sought for the operational phase
	PMB201193(1)		Bed and banks permit to construct a vehicle crossing over the Lyons River and other drainage channels Additional permits will be sought where linear infrastructure crosses drainage channels.
Dangerous Goods Safety Act 2004	-		Dangerous Goods such as fuel stored on the premises will subject to Dangerous Goods storage licensing requirement
Mining Act 1978	72489 and 73946		Applicant has existing approval of Mining Proposal and Mine Closure Plan for the 'minor or preliminary works.' Requirement to obtain a project-wide Mining Proposal and Mine Closure Plan approval.
Radiation Safety Act 1975	-		Registration of premises for mineral exploration issued by Radiological Council. NORM will apply to operational phase of the Yangibana Project therefore approval will be sought for registration of the premises and the operations Radiological Management Plan.
Part IV of the EP Act (WA)	s.41A(3) approval		EPA consent to minor or preliminary works for investigative and mineral exploration activities
	s.43A approval		EPA approval of proposal changes
	s.43A approval		EPA approval of proposal changes
	Ministerial Statement 1110		Minister for Environment approval of the Yangibana Rare Earths Project, subject to conditions.
Part V of the EP Act	W6158/2018/1		Construction of screening plant, landfill and sewage facility associated with preliminary site investigations and exploration

5.2 Part IV of the EP Act

5.2.1 Background

The Applicant referred the Yangibana Project to the EPA under s38 of the EP Act in January 2017. The level of assessment was set at Public Environmental Review (PER) in February 2017. The proposal scope of assessment for the EPA included five open mine pits, tailings facilities and ancillary infrastructure to support the mining operation.

During EPA assessment of the proposal there was a s.41A(3) of the EP Act approval granted on 25 August 2017 to allow minor or preliminary works within the proposal development envelope associated with water investigations, geotechnical assessments, environment surveys and mineral exploration activities. It also includes works for the construction of an accommodation village with associated sewage treatment facility, irrigation field and access roads.

There were also two s.43A of the EP Act changes to the proposal approved during the assessment as follows:

- June 2018 - Changes to the development envelope for the proposed airstrip, a Borefield and water pipeline along with increased TSF capacities; and
- May 2019 – Changes to the TSFs to combine TSF1 and TSF2 (into the Beneficiation TSF) and TSF3 and the evaporation (into the Hydromet TSF) along with increased TSF capacities. A change to the deposition methodology of the Beneficiation TSF from central thickened discharge to perimeter discharge in a paddock style design was also approved.

The EPA published Report 1642 in June 2019 (EPA Report 1642) which is its report and recommendations to the Minister for Environment on the proposal.

EPA Report 1642 identified the following key environmental factors during the course of its assessment:

- Flora and Vegetation – loss of flora and vegetation from clearing and indirect impacts such as altered hydrological regimes;
- Subterranean Fauna – direct and indirect impacts to subterranean fauna as a result of mining and groundwater abstraction;
- Inland Waters – changes to hydrological regimes as a result of mining and groundwater abstraction and, alteration of surface water flow, and groundwater and surface water quality;
- Terrestrial Environmental Quality – contamination of surrounding soil and land from erosion, dust and reduction of TSF integrity; and
- Human Health – potential impacts to human health from radiation exposure.

The EPA concluded in EPA Report 1642 that the proposal is environmentally acceptable and recommended the proposal be implemented subject to recommended conditions in Appendix 4 of the report. The EPA recommended conditions relating to the protection of flora and vegetation and subterranean fauna.

5.2.2 Ministerial Statement 1110

The Minister for Environment granted Ministerial Statement (MS) 1110 for the Yangibana Rare Earths Project under Part IV of the EP Act on 19 August 2019, subject to conditions. MS 1110 is published and available in full at www.epa.wa.gov.au. Conditions imposed relate to protection of flora and vegetation, and subterranean fauna.

Flora and vegetation conditions relate to:

- Avoiding where possible, and minimising direct and indirect impacts to specified vegetation units, listed priority flora and vegetation communities associated with claypans/depressions, drainage lines, creeks and riparian vegetation;
- Targeted vegetation surveys within and outside the development envelope prior to ground disturbing activities;
- Modelling to determine indirect impacts from altered surface water regimes on vegetation communities (as above) prior to ground disturbing activities;
- Prepare and submit a condition environmental management plan for the avoidance and minimisation of direct and indirect flora and vegetation impacts, including monitoring management actions targets and reporting;

Subterranean fauna conditions related to:

- Protection of stygofauna from mine groundwater drawdown during construction and operational phases;
- Prepare and submit a condition environmental management plant for the protection of stygofauna from mining groundwater drawdown, including specification of environmental outcomes, trigger criteria, thresholds, monitoring, actions, contingencies and reporting.

Condition 1-1 specifies the authorised extent of the proposal. This specifies that a maximum of 10 Mt of tailings are to be disposed into the Beneficiation TSF and not more than 777,000 t into the Hydromet TSF.

Key Finding: The conditions of MS 1110 address vegetation surveys, surface water modelling and a requirement for an environmental management plan to minimise impacts on significant vegetation and priority flora. Also limitations on mine pit groundwater drawdown to protect a PEC. Conditions in MS 1110 do not significantly affect the Part V EP Act assessment of emissions and discharges.

EPA Report 1642 makes note that emissions and discharges associated with the ore processing facility and TSFs will be regulated under Part V of the EP Act.

5.3 Federal legislation – EPBC Act

The proposal was deemed a controlled action under the EPBC Act, as it was determined that it will or is likely to have a significant impact on a Matter of National Environmental Significance (nuclear action).

The project was approved under the EPBC Act on 2 April 2020 with conditions (EPBC 2016/7845). Conditions were set in relation to the amount of permitted land disturbance within the development envelope approved under the Ministerial Statement MS 1110, and a limit set on the annual rate of groundwater permitted to be abstracted and from which aquifers. Conditions were also set in relation to protection of groundwater dependent ecosystems (GDEs). Refer to section 6.3 for further information on GDEs.

5.4 Department of Mines, Industry Regulation and Safety

5.4.1 *Mining Act 1978*

In its direct interest stakeholder advice, DMIRS confirmed that a Mining Proposal and Mine Closure Plan for minor and preliminary works for site investigations and related activities has been approved under the *Mining Act 1978* (reg ID 72489 and 73946).

The Applicant is required to obtain project-wide approvals under the *Mining Act 1976*. At the time of its advice (5 August 2019), DMIRS advised that the Applicant was yet to lodge a Mining Proposal and Mine Closure Plan for the main project and understood that some of the tenements were pending grant, and lodgment was likely to occur once the required tenure is live.

5.4.2 *Radiation Safety Act 1975*

Rare earth minerals may contain naturally occurring radioactive materials (NORMs). The Yangibana Project has NORMs at concentrations sufficient to require management under a Radiation Management Plan according to the *Mines Safety and Inspection Regulations 1995* and ARPANSA's *Code of Practice and Safety Guide for Radiation Protection and Radioactive Waste Management in Mining and Mineral Processing 2005*. These matters are primarily regulated by DMIRS on delegation from the Radiological Council (WA).

DWER, under Part V of the EP Act, also has a regulatory role in assessing the risks posed by emissions to the environment from the use and storage of processing wastes such as tailings, including radiological impacts.

Radiological aspects of the Application are further discussed in Section 8.

5.5 Part V of the EP Act

5.5.1 Applicable regulations, standards and guidelines

The overarching legislative framework of this assessment is the EP Act and EP Regulations.

The *Environmental Protection (Noise) Regulations 1997* specify the prescribed standards for noise emissions.

DWER guidance statements which inform this assessment are:

- *Guidance Statement: Regulatory Principles (July 2015)*
- *Guidance Statement: Setting Conditions (October 2015)*
- *Guidance Statement: Decision Making (April 2019)*
- *Guidance Statement: Risk Assessments (February 2017)*
- *Guidance Statement: Environmental Siting (November 2016)*

The Department's latest April 2019 version of the Landfill Waste Classification and Waste Definitions 1996 (LWCWD) provides criteria for acceptance of wastes at various classes of landfill in Western Australia. Guidance and definitions within the LWCWD are relevant to aspects of the Applicant's proposed burial of waste.

In June 2019, the Department published its *Guideline: Industry Regulation Guide to Licensing*. Among other matters, the guideline provides information on how the Department manages the transition of a prescribed premises from a Works Approval to a Licence.

5.5.2 Works approval history

Works Approval W6158/2018/1 was granted on 29 November 2018 for preliminary works for the Yangibana Project associated with investigative studies and mineral exploration. The works approval authorised the Applicant to undertake works to:

- Mobilise a crushing and screening plant to site to produce construction material for road base; and
- Construct a sewage facility and landfill for waste generated by the accommodation village.

The works approval contains conditions relating to the design and construction of the crushing/screening plant, sewage facility and putrescible landfill. It also authorises commissioning of the sewage facility for a period up to six months, subject to conditions.

The Works Approval was amended on 6 April 2020 to increase the capacity of the accommodation camp WWTP to 100m^3/day and the corresponding irrigation sprayfield area was increased from 1ha to 4ha. A further six months for commissioning was permitted.

6. Location and siting

6.1 Siting context

The Yangibana Project is located approximately 270 km east-northeast of the town of Carnarvon on Gifford Creek and Wanna Stations in the Gascoyne Region of Western Australia (see Figure 1). The Thiin-Mah Warriyangka, Tharrkari, Jiwarli (TMWTJ) people have a native title claim over the project area and beyond. The native title claimants are represented by the Yamatji Marlpa Aboriginal Corporation and the Application states that a Native Title Agreement with the TMWTJ group has been negotiated and ratified in November 2017.

The premises is classed as within the Gascoyne region and Augustus subregion under the Interim Biogeographic Regionalisation for Australia (IBRA). The topography is influenced by the Lyons River to the south, to a lesser extent the Edmund River to the east and a small range of hills to the north. The remainder of the area is characterised by subdued topography with rounded granitic hills and open flat areas cross cut by small dendritic drainages.

6.1.1 Naturally Occurring Radioactive Materials

The Application states that the majority of the rare earths at the premises are hosted by the phosphate mineral monazite, which contains low levels of thorium and uranium and their decay progeny. The presence of these elements is termed Naturally Occurring Radioactive Materials (NORMs) as they are derived from a geological source associated with the granite bedrock and successive hydro-thermal emplacement of ironstone dykes. Predominantly thorium and uranium radionuclides occur in the ore and are therefore recorded in the concentrate and tailings.

6.2 Residential and sensitive Premises

The distances to residential and sensitive receptors are detailed in Table 8. The Applicant has a worker accommodation village located within the premises boundary, approximately 9 km south west of the ore processing facility and approximately 7 km south west of the TSFs. The Department's *Guidance Statement: Risk Assessment* excludes employees, visitors or contractors of the Applicant as being considered receptors, as protection of these parties often involves different exposure risks, prevention strategies and is provided for under other State legislation. The accommodation village is therefore not considered a receptor for the purposes of the risk assessment.

Table 8: Receptors and distance from activity boundary

Sensitive Land Uses	Distance from Prescribed Activity
Gifford Creek Station Homestead	Approx. 15 km SSW of the ore processing plant and approx. 13 km SSW of the TSFs
Edmund Station Homestead	Approx. 24 km NW of the ore processing facility and approx. 25 km NW of the TSFs

6.3 Specified ecosystems

Specified ecosystems are areas of high conservation value and special significance that may be impacted as a result of activities at or emissions and discharges from the premises. The distances to specified ecosystems are shown in Table 9 which has regard to the *Guidance Statement: Environmental Siting*.

Table 9: Specified ecosystems

Specified ecosystems	Distance from the Premises
Priority Ecological Community (PEC): *Priority 1 (P1) Gifford Creek, Mangaroon, Wanna calcrete groundwater assemblage type on Lyons palaeodrainage on Gifford Creek, Lyons and Wanna Stations* This area is a PEC because it has a diverse stygofauna community located within the Lyons palaeodrainage channel.	The premises is located within the PEC.
Priority Flora: Eleven Priority Flora species (including six significant range extensions) according to EPA Report 1642.	Located within and surrounding the premises. The EPA Report noted that vegetation surveys to date have not necessarily met its guidance and standards and more targeted and detailed and targeted surveys are a requirement of MS 1110
Lyons River, Frasers Creek and associated tributaries/drainage lines	Lyons River – approx. 9 km SW of the TSFs Frasers Creek – passes approx. 1.5 to 2 km along the western side of the TSF and ore processing facility A creek or tributary of Frasers Creek transects between the northern perimeter of the TSF and south of the ore processing facility.

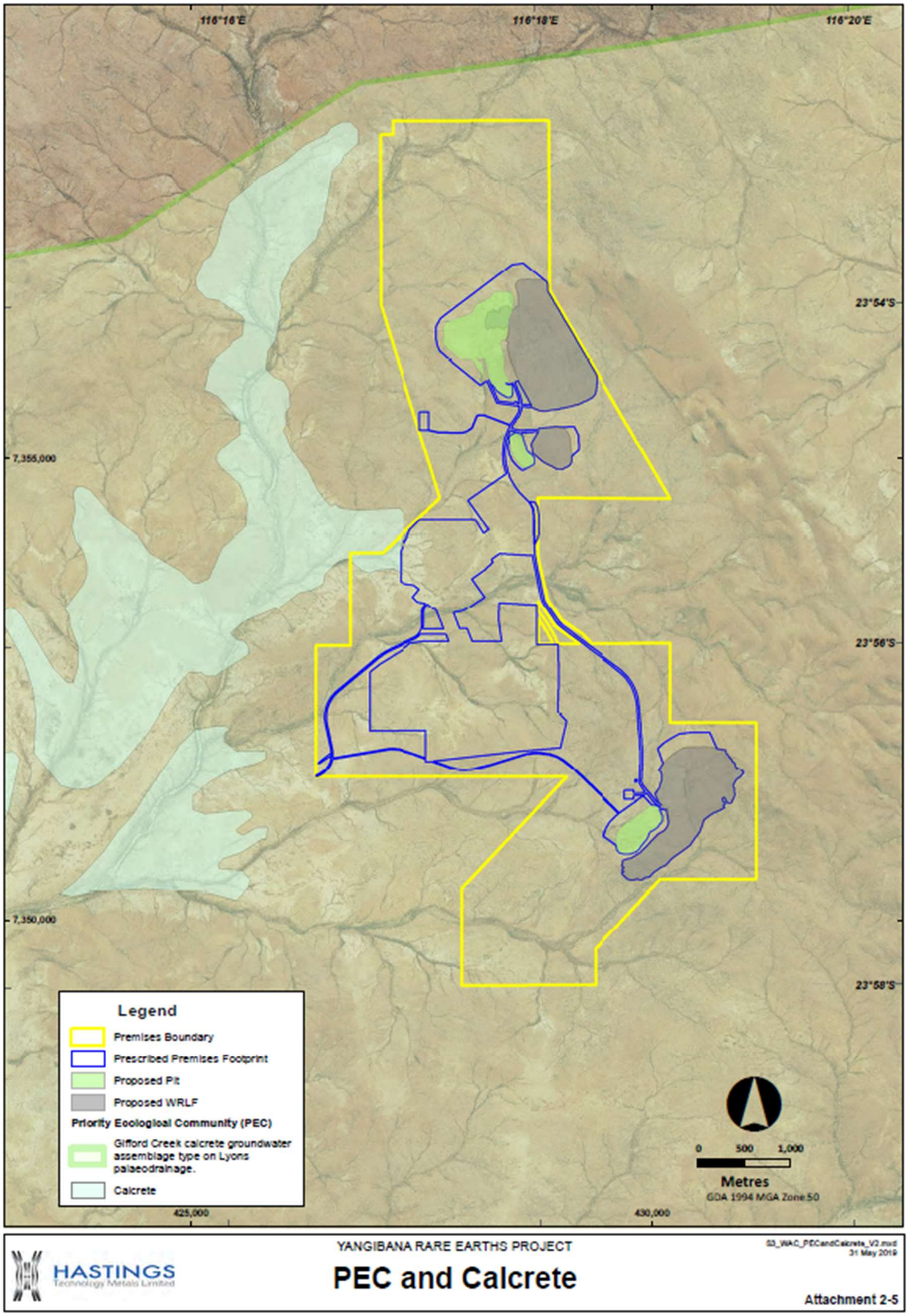


Figure 6: Priority Ecological Community (PEC) and Calcrete aquifers, shown in relation to the Premises.

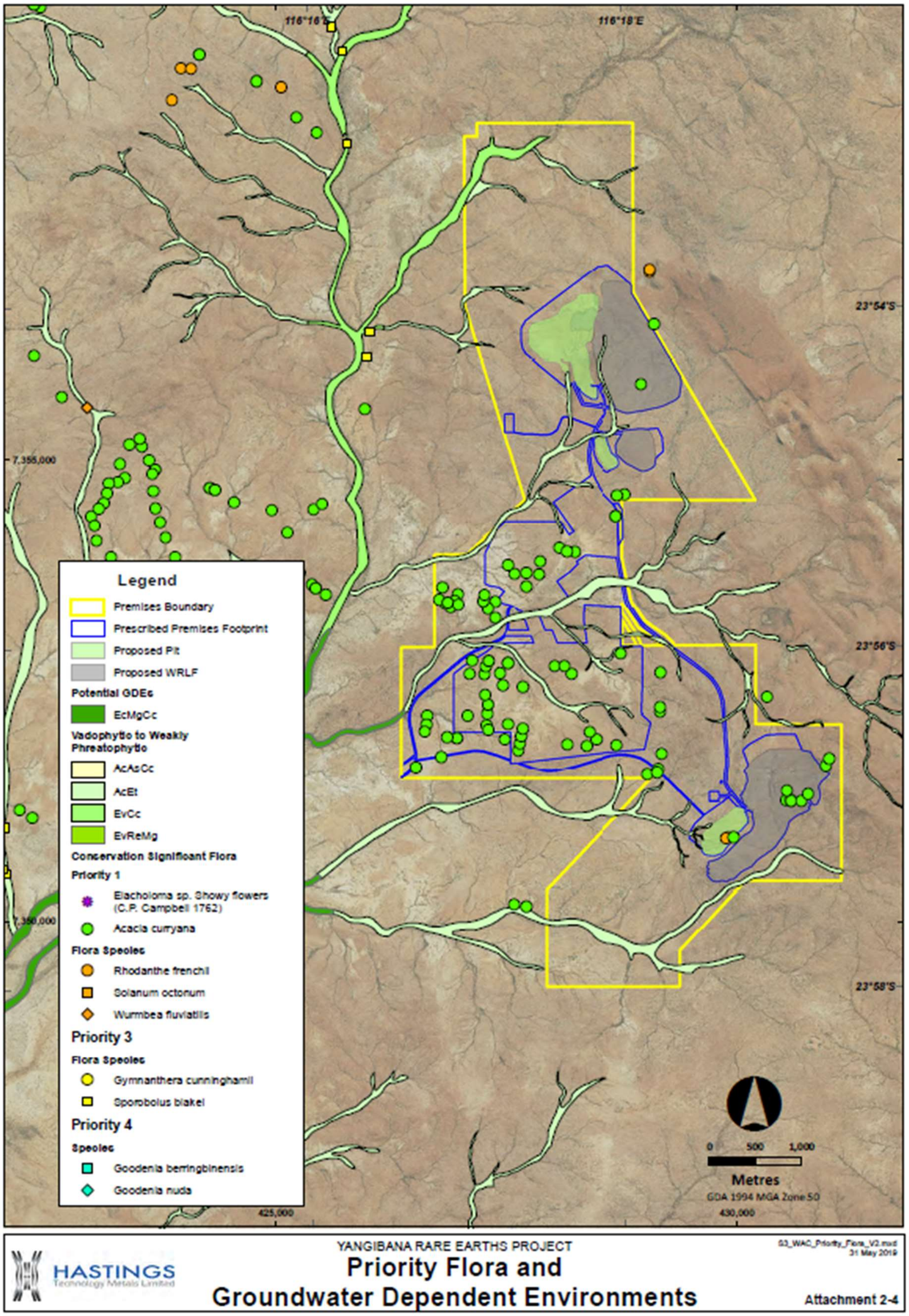


Figure 7: Location of Priority Flora and Groundwater Dependent Ecosystems (GDE) within Premises and immediately adjacent. Premises' boundary shown in yellow.

6.4 Surface water and groundwater

The Rare Earths Facility is located within the Gascoyne River Catchment which occurs within the Gascoyne Surface Water Proclamation Area and the Gascoyne Groundwater Proclamation Area.

Catchment flows are local north to south flowing ephemeral creeks and draining towards the Lyons River. The dominant drainage feature in the eastern belt mining area is Frasers Creek which passes to the western side of the proposed ore processing plant and TSF. Proposed infrastructure occurs within the local Fraser Creek Catchment in close proximity to Fraser Creek and some of its tributaries. The Lyons River is ephemeral and only flows following rainfall.

The Applicant provided surface water sampling results for two temporary pools within the Lyons River and Frasers Creek following a large rainfall event in October 2016. However, it did not consider the physical and chemical parameters recorded to be representative of surface water quality of flowing streams. The Applicant intends to undertake further sampling as part of on-going hydrological assessment.

Groundwater primarily occurs in fractured rock aquifers with localised water bearing calcrete and alluvial deposits adjacent to drainage lines and palaeochannels in the vicinity of the Lyons River and major creek lines. GHD, 2019 states that the hydrogeology of the area is characterised by a south westerly draining system, coincident with the Lyons River surface water catchment. The Application described the project area as characterised by local superficial aquifers and underlying fractured and weathered basement rock aquifers. It is considered that aquifers will be mostly unconfined with confined conditions occurring locally. The three aquifer types listed and described were:

- Superficial units with alluvium units in proximity to recharge along the main drainage lines forming aquifers with potential to supply usable sustainable quantities of groundwater. Generally likely to be unconfined but confined groundwater will be present locally where the aquifer is overlain by low permeability units;
- Basement rocks with fractured and weathered basement rocks forming isolated and effectively disconnected aquifers. Some degree of hydraulic connection will occur locally depending on factors. Permeability will be low, and regarded as effectively impermeable throughout much of the project area; and
- Palaeochannel systems at depth and may have connectivity to superficial units where recharge occurs.

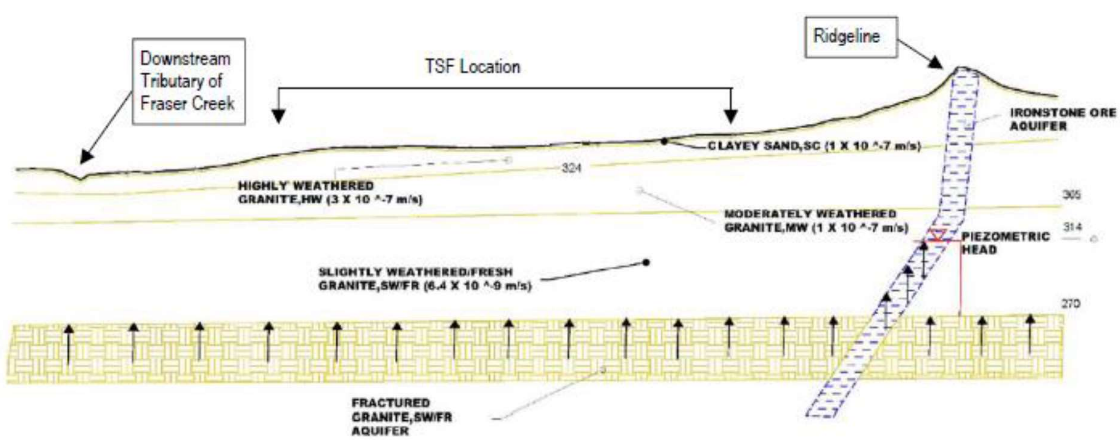


Figure 8: Conceptual hydrogeological model for the TSF Site (Source: Application)

GHD 2019 also notes that recharge to the aquifer system is likely to occur predominantly by stream flow from the dominant creeks and tributaries and through direct rainfall. The only noted groundwater users in the vicinity of the premises are the pastoral stations, with water used for domestic and stock purposes. The nearest pastoral bore (Frasers bore) was quoted as approximately 1-2 km from the prescribed premises.

The distances to groundwater and water sources are shown in Table 10. The pastoral bore and surface water drainages are depicted in Figure 9.

Table 10: Groundwater and water sources

Groundwater and water sources	Description and environmental value
Groundwater	From information in the Application, depth to groundwater ranges from 31.9 m at Fraser Well (nearest bore to the facility), 33.8 m at FRW03 (bore for early works, next to borrow pit on M09/158) and 26.52 m at BHW05. Depth to groundwater may be as shallow as 10 m or less in creeks and the Lyons River, where shallow calcrete aquifers are known to exist. The depth to groundwater in the palaeochannel tributary is between 90 m and 120 m. Sampling of pastoral bores and a limited number of bores and drill holes has indicated groundwater salinity from 600 to 2800 mg/L TDS and a pH neutral to slightly alkaline (7.2 to 8.6). Above detection limit concentrations of arsenic, boron, copper, iron, molybdenum, silicon, vanadium, tin, strontium, selenium and uranium, however values are below the ANZECC water quality guidelines for stock. Pastoral bores used for livestock water. Abstracted groundwater will be treated and utilised as the site's water supply.
Lyons River	Environmental values of surface water flow in the area are riparian vegetation, ephemeral pools within associated groundwater dependant ecosystems and a network of shallow calcrete aquifers associated with the Gifford Creek calcrete PEC (refer to Table 9). Several tributaries of the Lyons River transverse the premises, namely Yangibana and Frasers Creeks along with several drainage channels.
Bores	GHD 2019 states that a search of registered bores within a 20 km radius of Bald Hill was conducted using the Water Information reporting database, which indicated there were 15 bores within this radius. Application states there are pastoral bores located within the shallow calcretes along the Lyons River and Frasers Creek. The nearest pastoral bore is approx. 2 km from the TSFs.

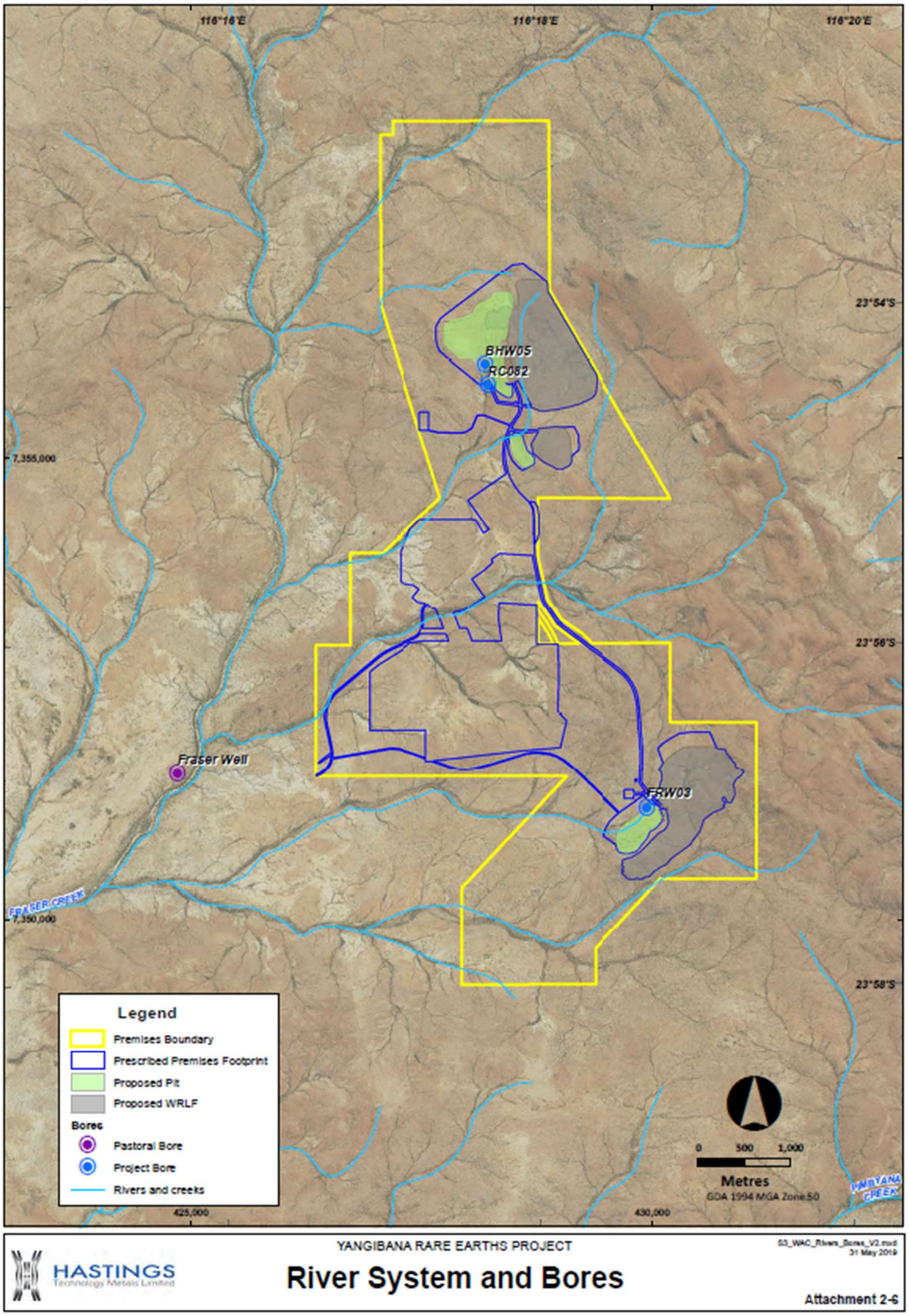


Figure 9: Location of nearest pastoral bore and surface drainage system

6.5 Soils

The Applicant quoted soil characterisation undertaken by Landloch Pty Ltd in accordance with *Guidelines for Mining Proposals in Western Australia* (DMP, 2016). The two main soil types recorded within the proposed disturbance footprint are:

- Dark brown sandy duplex soils ("Hills soils"): Associated with the extensive granite geology that forms the low hills and rises across the site, specifically the stone mantles and outcrops of granite and ironstone. This soil type can be divided into an A and B horizon overlying a C horizon of decomposing granite. Soil depths vary from ~20cm up to 50cm. It is considered neutral to slightly acidic that does not vary much through the profile or between sample locations. It is characterised by low salinity levels and a maximum exchangeable sodium percentage below 6%, indicating it is a non-sodic soil; and
- Dark brown sandy loam over clay loam soils ("Plains soils"): Associated with low relief areas and flood plains of drainage lines. This soil type can be divided into A and B horizons - a thin sandy loam topsoil over clay loam with an overall shallow depth (<30cm). It is strongly alkaline, saline and sodic. Two variations within this soil unit were identified. One variation, associated with drainage lines, will not be impacted by the Project. The second variation has a deeper profile, saline, sodic and clay-rich and has greater mottling. This soil unit variation will interact with proposed mine infrastructure and has the potential to be difficult to manage.

6.6 Meteorology

The Application refers to Bureau of Meteorology (BoM) climate mapping summary information for the Yangibana Project area that it accessed at www.bom.gov.au/climate on 31 May and 1 June 2016.

Table 11: Climatic description for the Yangibana Project area (Source: Application)

Mapping	Description
Major seasonal rainfall zone – climate class	Arid, low rainfall
Climate zone based on temperature and humidity	Hot dry summer, mild winter
Average annual rainfall	200-300 mm
Average annual pan evaporation	2800 – 3000 mm

The premises is subject to norther northern monsoonal influences over the summer and early autumn period, and southern frontal influences in late autumn and winter. There are two periods of higher rainfall from January to April and June to July, with a drier period from August to December.

7. Air emissions modelling/ studies

7.1 Plume study

The Applicant undertook plume study investigations, including dispersion modelling, for emissions from the Acid Bake Kiln (ABK) and Sulphuric Acid Plant (SAP) stacks. Plume study information was considered in its entirety, however as noted in sections 2 and 4.2, the Applicant notified DWER on 15 January 2020 that they had deferred the SAP from the application while further air emissions investigations were undertaken. Accordingly, only aspects relating to the ABK emissions to air are discussed in this section.

The initial plume study (ERM 2018) modelled sulfuric acid mists (H_2SO_4), sulfur dioxide (SO_2), hydrogen fluoride (HF), oxides of nitrogen (NOx) and particulate matter with aerodynamic diameter less than 10 micrometres (PM_{10}) to predict ground level concentrations and potential impacts from ABK air emissions.

ERM 2018 considered two stack exit velocities, a range of different potential stack heights and worst case impacts associated with two operational scenarios (normal and emergency operations). Predicted ground level concentrations were modelled at twenty discrete receptors including seventeen within the premises boundary, the accommodation village and two station homesteads (approx. 15 km SSW and 24 km NW of the ore processing facility respectively). Note that the Delegated Officer has not considered the accommodation village to be a receptor for the purposes of risk assessment as discussed in section 6.2 and potential health and safety impacts of worker exposure within the premises are also not within the scope of assessment. However, the risk of impacts to flora and fauna is within scope.

The key observations from a review of ERM 2018 were as follows:

- Uncertainty in the chosen stack height for the ABK design;
- Potential exceedance of the conservative maximum hourly H_2SO_4 concentration at the Accommodation Village (R18) for the emergency scenario (although noting the Accommodation Village is within the scope of risk assessment). Provided risk calculation return intervals were noted and while the calculation method appeared reasonable, the fill workings were not provided;
- Non-critical issues with the modelling and reported results;
- Predicted ground level concentrations at the homestead receptors were low percentages of standards (NEPM guideline values or the Department's 2019 draft *Guideline: Air Emissions*) during normal operations and worst case stack configuration (i.e. smallest stack heights and low flow condition for scrubber stack); and
- A conservative screening tool was used to investigate HF emissions against a 24 hour HF standard (2.9 $\mu g/m^3$) proposed to be adopted within the Department's 2019 draft *Guideline: Air Emissions* for the protection of general vegetation. The conservative screening results indicate potentially elevated levels in the vicinity of the processing plant during normal operations with the 30m stack configuration. Noting it was conservative screening, there is still the potential that levels exceed the 2.9 $\mu g/m^3$ criterion once other factors are considered through more robust investigation.

Several of the findings were discussed in more detail with the Applicant who provided additional information included a revised plume study (ERM 2019) which was further reviewed as part of this assessment. Of note, revised modelling in ERM 2019 included updates to stack parameters, additional operating scenarios, modelling of carbon monoxide (CO) emissions, selected 35 m ABK stack heights and comparison to more recent changes to air quality criteria (i.e. consideration of values in the DWER 2019 draft *Guideline: Air Emissions* and consideration to a proposed variation to NEPM criteria).

The ABK predicted ground level concentrations of H_2SO_4, SO_2, HF, PM_{10} and CO at the two homestead receptors (and the Accommodation Village) for the start-up, normal, upset and emergency scenario compared to criteria are provided in full in Appendix 3. Findings include:

- Predicted exceedance of the 3-minute average H_2SO_4 criterion at the Accommodation Village during ABK emergency release. The prediction is on the assumption that worst case meteorological conditions coincide with the emergency release.
- Risk analysis indicated the probability of a H_2SO_4 air quality criteria exceedance due to an ABK emergency scenario is estimated to be 1 hour in over 500 years at all receptor locations.
- HF emissions are no longer predicted to exceed assessed criteria including the DWER 2019 draft *Guideline: Air Emissions* value for protection of general vegetation.

7.2 Ammonia gas evolution

As a consequence of revising the TSF proposal to combine former TSF3 and evaporation pond liquors into a single Hydromet TSF, there was a recognised potential for ammonia (NH_3) gas to be produced due to the reaction between caustic soda from the gas scrubber waste and ammonium sulfate from the evaporation pond liquor.

The Applicant engaged consultants to undertake further assessment work on Hydromet TSF NH_3 gas evolution risks. GHD initially investigated predicted daily NH_3 generation rates under a range of pH conditions including a worst scenario involving a pH of 11.3 along with a worst case waste stream reporting to the Hydromet TSF at 76 t/h, containing approx. 0.04 g/L ammonia bicarbonate and 6.28 g/L of ammonia hydroxide solution. GHD 2019 concluded that as the Hydromet TSF was likely to have a pH of 10 or greater, it could be expected that greater than two thirds of the ammonia/ammonium incoming to the pond would escape to atmosphere as ammonia off-gas in the range of 3,900 to 5,300 kg/day based on the worst case scenario. GHD 2019 believed the environmental, health and safety risk implications required further modelling to quantify potential risks.

ERM 2019 subsequently outlines a screening level air quality assessment of ammonia emissions from the Hydromet TSF (Table 12). The ground level concentrations were evaluated at onsite and offsite receptor locations and compared against NH_3 ambient and occupational health and safety criteria.

Table 12: Ammonia reference criteria used by the Applicant (Source: GHD 2019)

	Averaging Period	Value	Unit	Value Qualifier	Source
Ambient air	24-hour[a]	104	µg/m³	Maximum	Ontario Ministry of Environment (Ontario Ministry of the Environment, 2012)
Ambient air	1-hour[a]	0.33 330	mg/m³ µg/m³	99.9th percentile	NSW EPA (NSW EPA, 2017)
Ambient air	3-minute[a]	0.6 600	mg/m³ µg/m³	99.9th percentile	Victoria Government Gazette (Government of Victoria, 2001)
OHS	8-hour[b]	25 17[a]	ppm mg/m³	Maximum	Australian Occupational Exposure Standards (Safe Work Australia, 2018)
OHS	15-minute[c]	35 24[a]	ppm mg/m³	Maximum	Australian Occupational Exposure Standards (Safe Work Australia, 2018)

Note:

a. Values at 273K and 101.3kPa

b. Time Weighted Average (TWA)

c. Short Term Exposure Limit (STEL)

The summary modelling observations in ERM 2019 were as follows:

- No exceedances of air quality criteria were predicted at the identified offsite sensitive Receptors;
- One exceedance (25.75 mg/m^3) of the 15-min OHS criteria was predicted at an onsite receptor (TSF receptor 1) located within 250 m from the centre of the source (Figure 4-1) This exceedance occurred under worst-case conditions. The next worst case scenario predicted a concentration of 12.89 mg/m^3 at this same receptor. This concentration is well within the criteria (50% of the criteria).
- In summary, the modelling results indicate that the maximum concentration is of low likelihood to occur and dependent on concurrence of worst case emission rate and worst case dispersion conditions (i.e., prevalence of calm conditions, transition from stable to unstable meteorological conditions, and winds blowing towards this receptor).

Subsequent to both GHD 2019 and ERM 2019 assessments of NH_3 gas evolution, the Applicant made additional refinements to the plant design (such as combining the former TSF3 and the evaporation pond into the Hydromet TSF) which suggested a revised set of chemistry in off gas absorbing and dual alkali caustic regeneration. Mass balance assumptions were updated with a lowering of pH under the worst case scenario from pH 11.3 to below pH 9. GHD 2019 states the change to the worst case scenario is significant as the amount of NH_3 generation is proportional to pH. A reduction of the pH to below 9 is expected by GHD 2019 to significantly reduce the generation of NH_3 under the worst case scenario and provides assurance that the

GHD and ERM assessments were very conservative and hence the risks associated with NH_3 gas evolution are suitably low and manageable.

8. Tailings assessments

The Rare Earths Facility will generate in excess of 10 Mt of tailings that will be deposited in the Beneficiation TSF (approx. 93%) or Hydromet TSF (approx. 7%). This section discusses the key tailings characteristics that inform the subsequent risk assessment of potential emissions and discharges.

8.1 Source characterisation

Rare earth element minerals at the Yangibana deposits occur within the Gifford Creek Ferrocarbonatite Complex, a suite of intrusive rocks that have been derived from a magma with a high carbonate content. The ore in these deposits occurs in iron-rich veins that have intruded into granitic rocks and been highly altered by high temperature fluids containing very high concentrations of potassium and sodium through the process of "fenitisation."

Most of the rare earth elements in the deposit occur within monazite, and consequently the recovery of these elements requires extensive processing to extract these elements from this highly stable mineral. The proposed ore processing comprises a grinding and flotation circuit, followed by an acid kiln bake and then a leaching phase to recover the rare earths. These processes have the potential to release other chemical constituents of environmental concern that could be leached from tailings materials.

Although carbonatite-hosted rare-earth deposits have a limited capacity to produce acid drainage because of their low sulfide and high carbonate mineral contents (Verplanck *et al*., 2014), these deposits contain readily soluble minerals that have the potential to release toxic chemical constituents on disposal to waste rock dumps (for example, the rare-earth and uranium containing carbonate mineral batnäsite), particularly if acidic residues from mineral processing are co-disposed with tailings. Additionally, the fenitised host-rocks contain a range of silicate minerals that contain toxic chemical constituents such as fluoride, lithium and thallium which can weather at a much faster rate than standard rock-forming minerals in granitic rocks, providing another potential source of harmful chemical constituents in TSFs and waste rock dumps.

8.2 Tailings geochemistry

As discussed in the Section 4.5.2 overview of the TSFs, tailings streams from the Beneficiation Plant were initially to be deposited into TSF1 and TSF2 along with a return water pond for TSF1. Hydromet Plant tailings streams were to be deposited into a TSF3 with an evaporation pond. Initial geochemical investigations and test work on this configuration were documented in ATCW 2019.

The Applicant altered the TSF configuration resulting in the Beneficiation TSF receiving the combined streams from TSF1 and TSF2 with an incorporated decant pond. The Hydromet TSF now combines the TSF3 and evaporation pond streams. Data and analysis for the former configuration was reconsidered and additional geochemical test work undertaken and documented in GHD 2019.

8.2.1 Geochemistry of Beneficiation TSF tailings

As noted in EPA Report 1642, the Beneficiation TSF tailings were considered by the Applicant to be benign with slight to moderate enrichments of metals (fluoride and molybdenum) in the solid tailings and contact water.

Based on the LEAF test work and past investigations (i.e. ASLP tests, leach testing with deionized water as well as groundwater, and other static tests), GHD 2019 concluded there is a low likelihood that metals in the Beneficiation TSF tailings solids will become soluble under the expected pH range (approx. pH 11.8).

The characterisation testing and summary outcomes for the solid and liquid portions of former TSF1 and TSF2 are provided in Table 13, as taken from GHD 2019.

Table 13: Former TSF1 and TSF2 geochemical analysis summary (Source: GHD 2019)

Characterisation	TSF 1		TSF 2	
	Solids	Liquids	Solids	Liquids
AMD testing (ATCW, 2019; Trajectory and GCA. 2017)	NAF	Circum Neutral/Saline	NAF	Circum Neutral/Saline
Suite of multi-elements (ANSTO, 2017; Trajectory and GCA, 2017)	No significant elevations but enriched in Al, Fe and Mn	Elevated F and Mo	No significant elevations but enriched in REE and Pb	Elevated F and Mo
Physical characteristics (ATCW, 2019; Trajectory and GCA, 2017)	Sodic	N/A	Sodic	N/A
Fibrous materials testing (Trajectory and GCA 2017)	None detected	N/A	None detected	N/A
Radionuclide concentrations (ANSTO, 2017)	0.7 Bq/g	Not significant; below detection limits	4 Bq/g	Not significant; below detection limits
pH	10-11	10-11	10-11	10-11

The Applicant undertook further geochemical testing in consultation with DWER and to reflect the change in TSF configuration to combine TSF1, TSF2 and return water pond streams into a consolidated Beneficiation TSF. The additional test work performed is listed in Table 14.

Table 14: Summary of additional geochemical test work (Source: GHD 2019)

Parameter	Tailings Solid	Pore Water	LEAF leach testwork
Net Acid Production Potential (NAPP)	X		
Net Acid Generation (NAG)	X		
Kinetic Net Acid Generation (KNAG)	X		
Acid Buffering Characteristic Curve (ABCC)	X		
Total Metals by inductively coupled plasma mass spectrometry (ICPMS) Full Suite	X (mg/kg)	X (mg/L)	X (mg/L)
Total Mercury	X (mg/kg)	X (mg/L)	X (mg/L)
pH and EC (1:5) (µs/cm and pH Unit)	X	X	
General Water Suite (mg/L)		X	
Suspended solids (mg/L)		X	

The summary geochemical characteristics of Beneficiation TSF combined tailings are provided in Table 15 below. The characteristics align with the former TSF configuration characterisation.

Table 15: Summary of Beneficiation TSF characterisation (Source: GHD 2019)

Characterisation	Beneficiation TSF	
Characterisation	Solids	Liquids
AMD testing	NAF	Alkaline/Saline
Suite of multi-elements	No significant elevations	Elevated F and Mo
Physical characteristics	Sodic	N/A
Radionuclide concentrations	0.8 Bq/g	Not significant; below detection limits
pH	10.1	11.8

Further discussion is provided below on results relating to LEAF testing and pore water analysis:

1. LEAF 1313 testing

LEAF 1313 testing was undertaken by the Applicant on a combined beneficiation sample with results of five pH conditions (pH 13, 12, 10.5, 7 and 2) then a further four conditions (pH 9, 8, 5.5 and 4). This covers the extreme range for LEAF leaching (2 – 13) and pH levels closer to expected site conditions (12 and 10.5). Plant filtrate has a pH of 11.8.

The full results are provided in Table 39 and Table 40 of Appendix 3 in comparison to ANZECC 2000 livestock drinking water, NEPM 2013 groundwater investigation levels and ANZECC 2000/2018 default guideline values for 95% protection of freshwater aquatic ecosystems. Summary exceedances for pH 12 and 10.5 were as follows:

- Results from pH 12 reported no exceedances of ANZECC 2000 livestock drinking water guidelines and NEPM 2013 groundwater investigation levels. Chromium (0.001 mg/L), silver (0.0005 mg/L) and copper (0.002 mg/L) exceeded the NEPM 2013 groundwater investigation guidelines. However, silver reported at the detection limit (<0.001 mg/L) which is much higher than the guideline value, reports at detection limits in all leaches and may be a low risk quality issue. Copper is suspected to be caused by the reagents or equipment and chromium is reporting at the guideline value which is also the detection limit value.
- Results from pH 10.5 reported exceedances of ANZECC 2000 livestock drinking water guidelines for manganese (2.35 mg/L) but fall within a 10X dilution factor discussed below. Exceedances exist for both NEPM 2013 guidelines of barium, cadmium, lead, manganese, nickel and silver. However these are also within a 10X dilution factor and some exceedances (i.e. copper and lead) are suspected of being caused by reagent/equipment contamination.

Due to the leaching procedure's relatively aggressive nature and the potential for dilution in the environment, GHD 2019 referred to DWER 2019 in stating that a dilution factor of 10 can be applied to the LEAF results when considering their environmental significance. This dilution factor is intended to apply to WA coastal sandy soils for beryllium and molybdenum, however, and may not be applicable for all elements at Yangibana.

The pH 12 leach test, closest in pH to the expected plant filtrate (pH 11.8) indicated elements of interest in that Beneficiation TSF tailings leachate remain molybdenum and fluoride, in addition to copper and chromium. Copper and chromium were above the corresponding guidelines for 95% protection of freshwater aquatic ecosystems (ANZECC 2000), however it is noted this does not account for potential dilution effects. The pH 13 test recorded a fluoride leach concentration of 4.1 mg/L (relevant guideline being 2 mg/L for livestock water quality) indicating that plant pH control will be important in managing fluoride concentrations in decant and tailings.

2. Combined pore water quality

The Applicant compared the plant filtrate results to the ANZECC 2000 livestock drinking water guidelines, ANZECC 2018 default guideline values for 95% protection of freshwater aquatic ecosystems, Australian drinking water guideline values and ASC NEPM 2013 groundwater investigation levels (provided in Table 39 and Table 40 of Appendix 3). The filtrate results reflected the conditions expected in the combined beneficiation liquid and reported a pH of 11.8 and an electrical conductivity (EC) of 5220 us/cm. Other results included:

- Chloride at 285 mg/L - no applicable ANZECC 2000 livestock or NEPM 2013 guidelines
- Sulfate at 182 mg/L - less than the ANZECC 2000 livestock and NEPM 2013 guidelines of 1000 mg/L and 5000 mg/L respectively
- Fluoride at 2.6 mg/L - exceeded the ANZECC 2000 livestock guideline of 2 mg/L and Australian 2011 drinking water guideline of 1.5 mg/L
- Total dissolved solids at 3390 mg/L – less than the ANZECC 2000 upper range for livestock of 5000 mg/L
- Alkalinity tests found the majority came from hydroxide at 703 mg/L followed by carbonate at 213 mg/L with bicarbonate at detection limit.

The above filtrate results characterise the initial expected condition onsite, however further test work was done on key elements fluoride and molybdenum to identify whether repeated recycling of process water would increase the concentrations.

Locked cycle test work for 15 cycles recorded fluoride and molybdenum in the final 3 cycles, with fluoride concentrations of 4 mg/L, greater than the plant filtrate (2.6 mg/L). The final 3 cycles showed similar concentrations in fluoride indicating a stabilisation. The final molybdenum reported at 2.5 mg/L exceeded the ANZECC 2000 livestock guideline value (0.15 mg/L) and Australian drinking water guideline (0.05 mg/L) but also stabilised in the final 3 cycles. GHD 2019 noted the test was designed under locked cycle conditions, however the current water modelling for the site indicates in steady state the process will operate on a mix of 80:20 recycled water to fresh raw water which is expected to produce lower concentrations.

Testwork indicates that fluoride and molybdenum levels in the Beneficiation TSF pore water are therefore elevated.

The Applicant considers it unlikely that fluoride will build up in the process water as lime ($CaCO_3$) is added to the beneficiation streams as a coagulant. This results in the precipitation of the sodium silicate reagent as a silicate. At a pH of 11-11.3, which is required for the coagulation process in this stage, the addition of lime will also precipitate the fluoride as calcium fluoride.

The solubility of molybdenum progressively increases in solution with increasing pH due to the formation of highly soluble molybdate and polymolybdate ions and may progressively increase in concentration in the processing circuit. The Applicant has committed to monitoring molybdenum levels in the recycled process water and to determine a trigger limit in the event of an increasing trend.

There are no ANZECC default toxicant guideline values for freshwater ecosystem protection for either molybdenum or fluoride.

8.2.2 Geochemistry of Hydromet TSF tailings

As noted in EPA Report 1642, the Hydromet TSF tailings were found by the Applicant to be slightly acidic and NAF with high levels of magnesium sulfate (MgSO4), thus exceeding the ANZECC 2000 livestock guideline for sulfate. Elevated levels of fluoride in pore water were also recorded, along with elevated molybdenum in tailings solids. The Hydromet TSF is classed as radioactive as the hydrometallurgical tailings stream will have an average radionuclide concentration of 33 Bq/g.

The characterisation testing and summary outcomes for the solid (TSF3 only) and liquid portions of the former TSF3 and evaporation pond configuration are provided in Table 16 (GHD 2019).

Table 16: Former Evaporation pond and TSF3 geochemical analysis summary (Source: GHD 2019)

Characterisation	Evaporation pond		TSF 3	
	Solids	Liquids	Solids	Liquids
pH and TDS	N/A	Circum Neutral/Saline	NAF	Circum Neutral/Saline
Suite of multi-elements/Salts	N/A	Elevated Mg, Mo, S, F, NH4 and Co	No significant elevations	Elevated Mg, SO4, S and Mo
Physical Characteristic	N/A	Will evaporate to a salt	Sodic	N/A
Fibrous materials testing	N/A	N/A	None detected	N/A
Radionuclides	N/A	None Detected	32.4 Bq/g	None detected
pH	N/A	7	6.6	6.6

The summary geochemical characteristics of combined Hydromet TSF tailings are provided in Table 17 below. GHD 2019 concluded that combining the two streams is unlikely to cause any reactivity of chemicals aside from ammonia hydroxide, at a high pH.

Table 17: Summary of Hydromet TSF characterisation (Source: GHD 2019)

Characterisation	Hydromet TSF	
	Solids	Liquids
AMD testing	NAF	Circum Neutral/Saline
Suite of multi-elements/Salts	No significant elevations expected	Elevations in Mg, NH4, S, SO4 Mo and F.
Physical Characteristic	Sodic	N/A
Fibrous materials testing	None expected	N/A
Radionuclides	32.4 Bq/g	Insignificant levels expected
pH	Expected to be between 6.6 and 7	Expected to be between 6.6 and 7

The Applicant advised that the Hydromet TSF will operate at a pH between 7 and 9.5 with a likely operational outcome somewhere between the two cases. While initially there was a consideration of conditions that may cause ammonia gas evolution from the tailings liquor, worst case modelling (refer to Section 7.2) at pH 10 indicates that the maximum concentration of ammonia emissions are of low likelihood to occur and dependent on the absolute worst case scenario emission rate in combination with poor ambient dispersion conditions.

1. Former TSF3 / Hydromet TSF solids

Testing on the solids that were to report to the former TSF3 indicated relative enrichment (compared to the Beneficiation TSF) in barium, chromium, nickel, lead, thorium, uranium, calcium, phosphorus and selenium. ASLP testing on TSF3 solids resulted in low concentrations of radionuclides and no significant leaching of any element.

GHD 2019 states that the solids component in the Hydromet TSF does not vary from that of the previously proposed TSF3 and no further assessment of Hydromet TSF solids was undertaken by the Applicant.

2. Former TSF3 and evaporation pond / Hydromet TSF liquor

Tailings pore water at pH 6.6 will contain levels of magnesium and sulfate several times in excess of ANZECC 2000 livestock drinking water guidelines. Total dissolved solids are elevated above background groundwater concentrations at 12,000 mg/L as compared to ~1400 and 2800 mg/L. The residue is lower in concentration of sodium, silicon, chloride, fluoride, nitrate but higher in calcium and manganese and of similar concentrations in aluminium and boron as compared to local groundwater quality.

The barren liquor that was to report to the evaporation pond was pH 7 neutral and expected to comprise of largely magnesium sulfate and ammonium sulfate solution. The revised design contains this liquor within the TSF3 footprint for evaporation.

Previous analysis of the TSF3 and evaporation pond liquors were used to estimate the combined Hydromet TSF liquor mass balance, which was then used to predict concentrations of key analytes (i.e. F, Mo, Mg, NH_4, SO_4, U and Th).

The mass balance as shown in Table 18, shows that the concentrations of key analytes in the former evaporation pond liquor have been diluted slightly by combining the two waste streams in the one Hydromet TSF. GHD 2019 states that verification of the geochemistry of the former TSF3 pore water will be completed at TSF start up and during TSF operation.

Table 18: Mass balance of Hydromet TSF (Source: GHD 2019)

Source	Mass (t)	F (mg/L)	Mo (mg/L)	Mg (mg/L)	SO4 (mg/L)	U (mg/L)	Th (mg/L)
TSF 3 liquor	114,155	0.5	0.5	3,050	15,900	0.5	0.5
Evaporation pond liquor	434,500	5	0.5	6,721	30,000**	0.5	0.5
Combined Hydromet TSF liquor	548,655	4.1	0.5	5,957.2	27,066.3	0.5	0.5

8.2.3 Radiological considerations

Due to NORMs in the ore and tailings, the Applicant undertook radiological assessments for activity concentration and exposure classification of tailings. This included testing by ANSTO including elemental assays of the tailings solids and liquid from a beneficiation and hydrometallurgical pilot plant, and the hydrometallurgical plant residue solution (decant). Leach testing on tailings solids was also undertaken under extreme low and high pH conditions.

Analysis of activity concentrations undertaken by ANSTO indicated that the majority of radionuclides are present in the solids fraction of the waste streams and have very low to low solubility. The results also indicate that both beneficiation tailings and hydromet tailings are in approximate secular equilibrium, which implies that the uranium and thorium concentrations can be used as an indicator of the other radionuclides in the decay chain.

The summary thorium and uranium concentrations provided in the Application are shown in Table 19.

Table 19: Tailings thorium and uranium concentrations (Source: from Application)

NORM	Beneficiation TSF		Hydromet TSF	
	Solids (mg/kg)	Liquids (mg/L)	Solids (mg/kg)	Liquids (mg/L)
Total activity concentration (TAC)	0.8 Bq/g	-	33 Bq/g	-
Uranium (U-238)	8.4	0.002	104	<1.0
Thorium (Th-232)	153	<0.001	7,623	<1.0

The average Beneficiation TSF tailings radionuclide concentration of approximately 0.8 Bq/g is less than the 1 Bq/g concentration and therefore not radioactive. There is potential that for a short period during commissioning and ramp-up, concentrations of radionuclides may reach up to 1.4 Bq/g, however the average concentration remains below the 1 Bq/g and the Beneficiation TSF is classified as a non-radioactive storage facility.

Further Applicant interpretation of the radionuclide concentrations in tailings pore water from leach testing showed that radionuclides in pore water are generally low with the majority of samples recording below minimum detection limits and similar to levels in regional pastoral bores.

The hydrometallurgical tailings stream is defined as radioactive as the tailings of the Hydromet TSF will have an average radionuclide concentration of 33 Bq/g. The concentration of radionuclides in the tailings pore water remain negligible.

In response to discussions with DWER, the Applicant interpreted radionuclide concentrations in tailings pore water from leach testing which were found to be generally low with the majority of samples recording below minimum detection limits and similar levels to levels in regional pastoral bores. Of all radionuclides, uranium (known to be slightly water soluble) was elevated in initial leaching solutions (0.302, 0.319 and 0.322 mg/L) from the first flush of former TSF1 solids with high purity deionized water, groundwater and humidity cells using high purity deionised water. Levels dropped to a range consistent with that recorded in regional pastoral bores (0.003 – 0.165 mg/L) in subsequent flushes (0.002, 0.097 and 0.115 mg/L) using the same series of flushing solutions. For reference the ANZECC 2000 livestock drinking water guidelines for uranium is 0.2 mg/L and the ADWG value, 0.017 mg/L.

Samples of tailings solids were subjected to ASLP testing using both acidic (pH 5) and alkaline (pH 9.2) leaching fluids. The results as summarised in GHD 2019, showed there was no significant leaching of radionuclides from any of the three TSF solids in the initial configuration using the acidic or alkaline leach testing fluids. Uranium-238 (0.02 mg/L; 0.25 Bq/L) was found in both the acetate and borate leachates extracted 1.9 and 1.3 % respectively of U-238.

Gross alpha was 0.96 Bq/L (pH 5), <0.05 Bq/L (pH 9) and <0.05 Bq/L (deionised water). Gross beta was 0.65 Bq/L (pH 5), <0.1 Bq/L (pH 9) and <0.1 Bq/L (deionised water). The highest concentration of any radionuclide was 0.81 Bq/L for Ra-228 in the acetate (acidic) leachate for the cleaner tails. Pilot plant filtrate gross alpha was <0.05 Bq/L and gross beta <0.1 Bq/L. By comparison, the ANZECC 2000 livestock drinking water guidelines provide the following trigger values for radiological quality:

- Radium 228 – 2 Bq/L
- Uranium 238 – 0.2 Bq/L
- Gross alpha – 0.5 Bq/L
- Gross beta (excluding K-40) – 0.5 Bq/L

8.2.4 DWER assessment

The geochemical assessment in GHD 2019 concluded that the Hydromet TSF contains elevated $MgSO_4$ and radionuclide and that the proposed lining system provides controls for containment and encapsulation of these contaminants. The key contaminants in the beneficiation TSF leachate for monitoring and management are fluoride and molybdenum and to a lesser extent chromium and possibly copper, noting GHD's commentary about potential contamination during the testing process. Mobilisation of radionuclides in leachate is low risk for the beneficiation leachate, however it is noted that at pH 13 the uranium concentration in leachate is above the ADWG value. A summary of key elements for each TSF is provided in Table 20.

.

Table 20: Summary of key analytes for each TSF (Source: GHD 2019)

Key element	Beneficiation TSF		Expected Hydromet TSF	
	Solids	Liquids	Solids	Liquids
Fluoride	-	2.6 mg/L	-	4.1 mg/L
Molybdenum	4.7	0.037 mg/L	161 mg/kg	<1 mg/L
Radionuclides	0.8 Bq/g	-	33 Bq/g	-
U Th	U = 8.4 mg/kg Th = 153 mg/kg	U = 0.002 mg/l Th = <0.001 mg/L	U = 104 mg/kg Th = 7,623 mg/kg	U = <1 mg/L Th = <1 mg/L
Mg	-	<1 mg/L	5,406 mg/kg	5,957 mg/L
SO4	(S = <0.01 %)	182 mg/L	(S = 9.3 %)	27,066.3 mg/L

It is noted that the geochemical assessment has not assessed the concentrations of rare earth elements (REEs) in leachate. It is likely that concentrations of many of the REEs in tailings pore water/leachate will be higher than natural background levels due to the processing that will be undertaken to release them from the monazite ore. Some of these elements are known or suspected of causing environmental harm when in soluble form (USGS 2010). Lanthanum is the only REE for which an Australian guideline value exists, with an ADWG value of 0.002 mg/L. While there are currently no ANZECC water quality criteria for REEs, there is increasing evidence that many of these elements are toxic to fauna and vegetation (USEPA 2012). The relatively high toxicity of these elements to aquatic organisms suggests that there are also likely to be potential health impacts to livestock that drink water that is contaminated with elevated concentrations of rare-earth elements. It is noted the Netherlands Ministry for the Environment has set the following concentration limits in freshwater to protect aquatic receptors from specific rare-earth elements as listed in Table 21. Consideration should also be given to site specific criteria development for REEs on the basis of an appropriate statistical analysis of background concentrations in groundwater in the vicinity of the mine site.

Table 21: Netherlands Ministry for Environment limits for rare-earth elements to protect aquatic receptors (Source: Table 9 of USGS, 2010)

Element	Concentration Limit (µg/L)
Yttrium	6.4
Lanthanum	10.1
Cerium	22.1
Praseodymium	9.1
Neodymium	1.8
Samarium	8.2
Gadolinium	7.1
Dysprosium	9.3

8.3 TSF design

The Application states that the TSFs have been designed to comply with the:

- Code of Practice for Tailings Storage Facilities in Western Australia, Department of Mining, Industry Regulation and Safety 9, DMIRS, September 2013;
- Guidelines on the preparation of a design report for tailings storage facilities (TSFs), DMIRS, August 2015; and
- Guidelines on tailings dams planning, design, construction and closure, ANCOLD, May 2012.

This assessment does not consider all aspects relevant to TSF design or the adherence and acceptability against relevant TSF guidelines and codes of practice. The design and operation of the TSFs, particularly with respect to safety and stability aspects, are subject to assessment by DMIRS through the Mining Proposal and Mine Closure Plan approvals required under the *Mining Act 1978* and via the *Mine Safety and Inspection Act 1994* and associated regulations. DWER's assessment is focused on TSF design and operational aspects as they relate to the risk of receptor impacts from emissions and discharges such as fugitive dust, fugitive vapours, and discharges from overtopping and seepage.

The proposed general arrangement for the TSFs (as depicted in Figure 10 and Figure 11 below sourced from GHD 2019) uses the natural topography where a number of small gullies are formed between subtle rises at ground level. The gullies are utilised to form respective Beneficiation TSF and Hydromet TSF embankments. The two TSFs are kept within a single compact footprint using a common shared dividing wall between them. The site impounds two adjacent gullies where there are respective watercourses feeding into the downstream Fraser Creek tributary. During operations, stormwater that falls within the TSFs will be contained and the upstream catchment will be diverted around the TSFs by a new diversion channel.

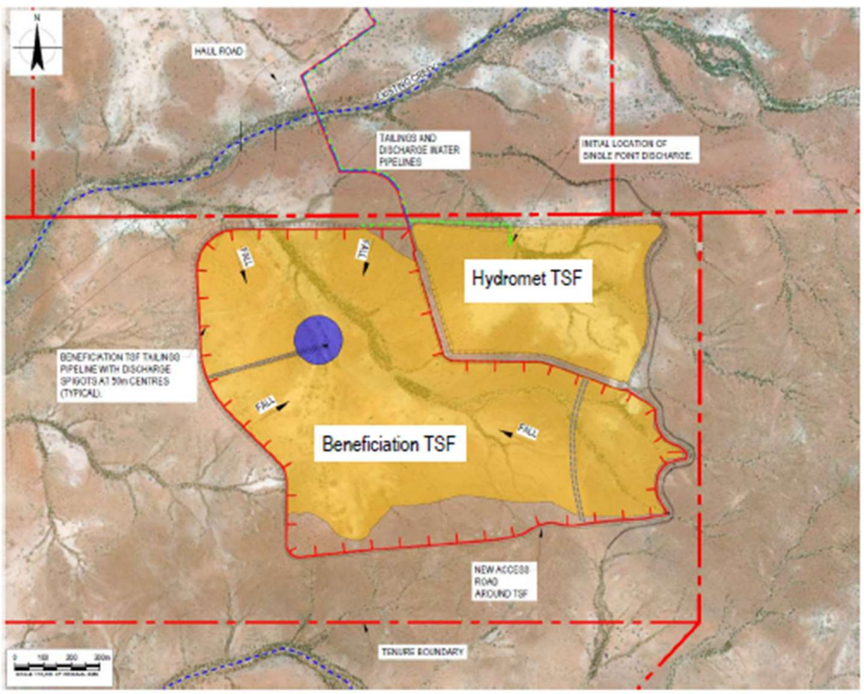


Figure 10: General arrangement of TSFs after 3 years (Source: Application, GHD 2019)

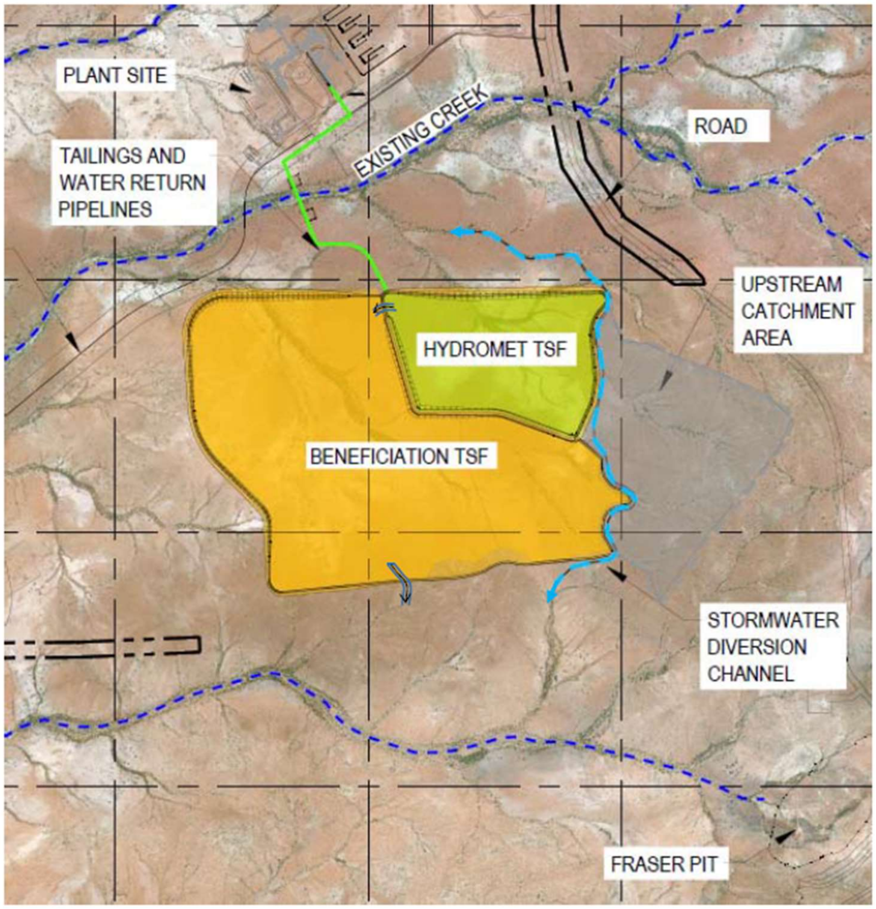


Figure 11: General arrangement of TSF including diversion channel and spillways

The Beneficiation TSF to be constructed first and will have an initial starter embankment, 6 m high at the maximum section for the first three years of production. The Applicant will increase this by 4 m over the life of mine to an ultimate approximate height of 10 m. Adjustments to the decant tower and access causeway will need to be made, including relocation to its final southern location at the end of mine life. Beneficiation TSF construction materials for low permeability zones within embankments will be sourced from external borrow areas but within the TSF footprint where possible and retention of near surface clayey deposits within the footprint to assist with seepage control.

The Hydromet TSF will also have an initial starter embankment 6 m high at the maximum section for the first three years of production. This will be increased by approximately 3 m over the life of mine to approximately 9 m ultimate height. The Hydromet TSF will have a geo-composite liner system of clay and a HDPE liner, as well as an underdrainage collection pipe in the valley of the TSF. The HDPE will be placed across the impoundment floor and on the upstream face of containment embankments.

The general design characteristics of the two TSFs are summarised in the two tables sourced from the Application under Table 22 below.

Table 22: Summary of TSF design characteristics

Tailings Facilities	Design	Maximum Embankment Height (m)	Discharge	Liner	Tailings	%Tailings	Encapsulation	Closure Capping	Embank-ment Closure
BENEFICIATION TSF	Paddock	11	Perimeter discharge with spigots	None	All beneficiation plant tailings	93	Nominal capillary break / erosion protection; growth medium (soil and rock armour).	500 mm thick benign mine waste rock. 200 mm topsoil.	2 m durable waste rock
HYDROMET TSF	Paddock	9	Single point discharge	Geocomposite liner; 300 mm CCL plus Geosynthetic Liner (1.5 – 2.0 mm HDPE)	All hydrometallurgical plant tailings	7	Compacted clayey sand base; CCL engineered capping with growth medium (soil and rock armour).	HDPE liner welded to basal liner 300 mm beneficiation tailings 500 mm benign waste rock. 200 mm topsoil.	2 m durable waste rock

Tailings Facilities	Crest Width (m)	Area (ha)	Design for Maximum Volume (Mm³)	Design for Maximum Solids Storage (Mt)	Approved Maximum Solids Stored (Mt)*
Beneficiation TSF	7	86	6.5 Mm³	9.745	10
Hydromet TSF	7	36	1.9 Mm³	0.72	0.77

The Applicant has determined the TSF stormwater storage capacity and freeboard allowances listed in Table 23 during mine operation in accordance with ANCOLD requirements.

Table 23: Applicant determined stormwater and freeboard criteria

Design criteria	Beneficiation TSF	Hydromet TSF
Stormwater storage capacity	1:5 wet season plus 1:100 AEP, 72 hr flood	1:5 wet season plus 1:100 AEP, 72 hr flood
Additional freeboard	nil	1:10 AEP wind run-up plus 0.3 m
Spillway	1:100,000 AEP, critical flood plus 1:10 AEP wave run-up or PMF (possible maximum flood)	1:100,000 AEP, critical flood plus 1:10 AEP wave run-up or PMF

The Beneficiation TSF decant area will capture tailings bleed water and incidental run-off from the catchment area associated with the TSF. This water is returned to the process water circuit via a water treatment/filtration plant for reuse. Due to the unsuitable water quality for plant reuse, there will be no water recovery from the Hydromet TSF. The Hydromet TSF will operate as an evaporation facility with adequate freeboard to contain stormwater inflows without spill for a 1:100 AEP, 72 hr rainfall event.

Emergency spillways are proposed for both TSFs at locations where they can be cut into natural ground to ensure durability of the structure. The Hydromet TSF spillway will have an orientation allowing it to spill into the Beneficiation TSF.

The tailings and return water pipeline route is also shown in Figure 10 with HDPE pipelines, a bunded piping corridor to contain spillage and spillage ponds at low points. A slurry pipeline located at the higher end of the catchment will traverse a river crossing that will have an elevated pipe bridge and double sleeved pipes in that area only. Spillage with otherwise be directed to low point spillage ponds or into the TSFs.

8.4 Seepage modelling

Potential environmental harmful species contained in the tailings solids (including radionuclides) identified in GHD 2019 are fixed or immobile, therefore it states the risk of adverse environmental effects associated with seepage is primarily governed by the seepage of transport water. Dissolved parameters in the tailings process liquor at concentrations above NEPM or ANZECC guideline values and/or local groundwater concentrations are:

- Beneficiation TSF – fluoride, molybdenum and pH; and
- Hydromet TSF – fluoride and magnesium sulphate

Seepage analysis was done by ATCW and presented in ACTW 2019 for the former TSF arrangement (three TSFs and an evaporation pond). GHD undertook supplemental seepage analysis for the Applicant relating to the refined TSF arrangement (two TSFs) which was presented in GHD 2019. GHD 2019 outlines the use of a concept level 2-D seepage analysis using the finite element software, Rocscience Slide.

ATCW 2019 modelling was limited to the former return water pond (RWP) and TSF2 since these were expected to have higher seepage potential relative to other TSFs that were proposed in the initial design. Similarly, GHD's modelling in GHD 2019 is limited to the Beneficiation TSF as the Hydromet TSF includes a geocomposite liner system that will ensure very small rates of seepage and negating the need for seepage modelling.

The conceptual model for the TSF area used for the seepage analysis is shown in Figure 12 (sourced from Figure 4-8 in GHD 2019) and is based on the soil and rock profile data obtained from the Applicant's geotechnical and hydrogeological studies.

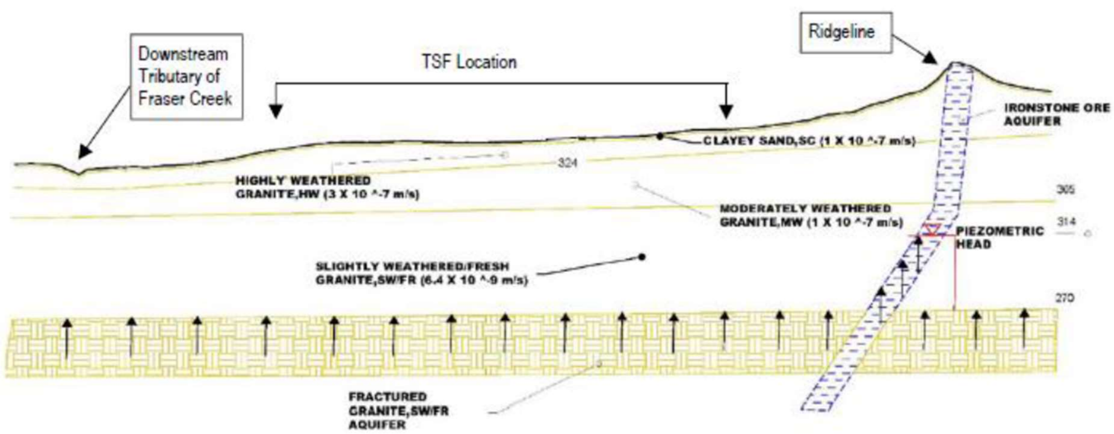


Figure 12: Conceptual hydrogeological model for TSF area (Source: GHD 2019)

GHD 2019 quoted the ACTW 2019 findings for the former RWP and TSF2 that "*the presence of confined water pressure in the aquifer below approximately 50 m depth and the presence of a very low permeability, unsaturated granite rock mass above this depth, the likelihood of significant downward seepage of water contained in saturated, very low permeability tailings stored at the ground surface is considered very low"*

GHD 2019 presents similar conclusions for the Beneficiation TSF that results of seepage analysis expected of the life of the facility are expected to remain within the TSF footprint with the majority of the ponding expected in the highly weathered to moderately weathered granite. The vertical seepage through the highly weathered to moderately weathered granite is shown in Figure 13 (sourced from Figure 9-6 in GHD 2019).

The Applicant's drawdown modelling for dewatering of the Bald Hill and Frasers pits indicates the proposed TSF site is likely to be outside the drawdown influence from the Frasers pit.

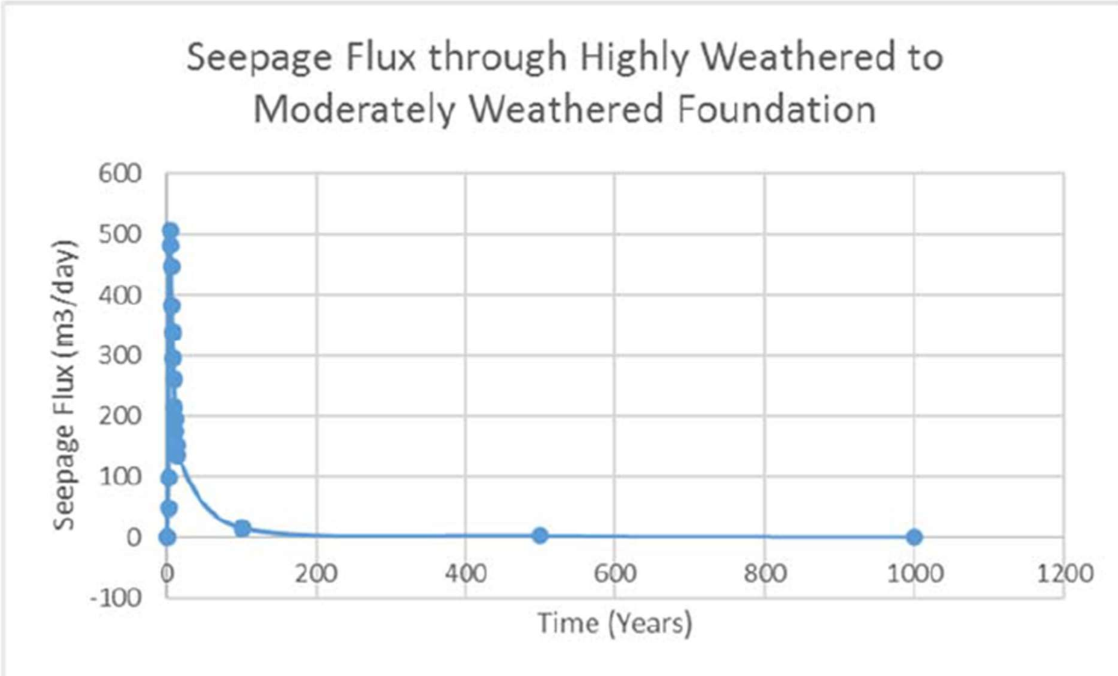


Figure 13: Highly weathered to moderately weathered vertical seepage rates (Source: GHD 2019)

9. Water balance

The Applicant outlined a water balance model prepared by GHD in GHD 2019 to assess the storage behavior and test the capacity of the Hydromet TSF for rainfall and tailings storage. Assumptions used in the model included:

- No external catchments report to the Hydromet TSF;
- Any overflow from the Hydromet TSF would report to the Beneficiation TSF via a spillway;
- No return water pumped from the Hydromet TSF; all available water will remain in the TSF to evaporate including free bleed water from the deposited tailings and incident rainfall;
- The Hydromet TSF was assumed to be empty at the start of the model (elevation 331.5 m); and
- No seepage losses will occur from the Hydromet TSF due to its lining.

The tested model scenario simulated the current plant operational settings to assess the viability and likely performance of the Hydromet TSF over a 10 year operational mine life with three rainfall scenarios; 20 percentile rainfall, 50 percentile rainfall and 80 percentile rainfall.

The resulting overall inventory of the Hydromet TSF is shown in Figure 14 as taken from Figure 9-5 in GHD 2019. The concluding analysis found that storage volume for the Hydromet TSF could support the total volume of tailings solids, free water and retained water for a 20, 50 and 80 percentile rainfall over a 10 year period, starting empty.

GHD 2019 states that water balance calculations indicate that due to the low discharge rate and high evaporation, a significant decant pond will not form in the Hydromet TSF.

GHD 2019 advised that a whole site GoldSim water balance will be undertaken during detailed design to confirm the site requirements and confirm the findings of the preliminary water balance.

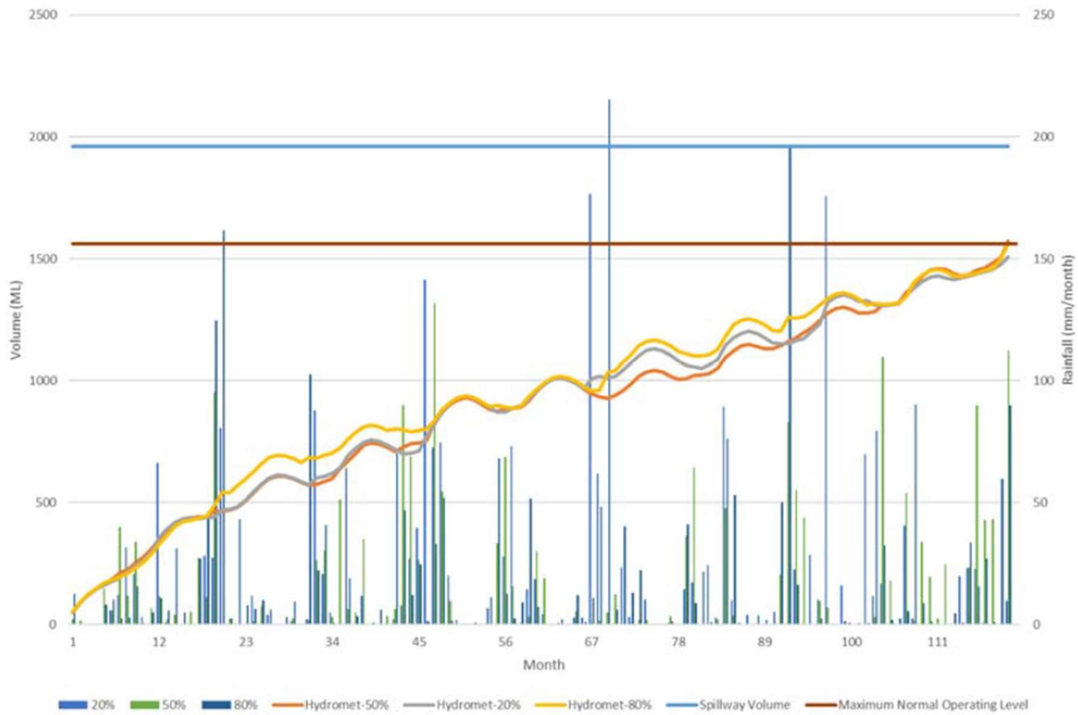


Figure 14: Overall Hydromet TSF inventory (Source: GHD 2019)

10. Consultation

The Application was advertised in the West Australian newspaper and on the Departments website for a 21 day public comment period. A copy of the Application was also published on the website. No submissions were received by DWER.

The Delegated Officer referred the Application to the following direct interest stakeholders seeking advice and comments:

- DMIRS;
- Radiological Council of W.A.; and
- Shire of Upper Gascoyne.

Advice from DMIRS noted that the Applicant had an existing Mining Proposal and Mine Closure Plan for minor and preliminary works for site investigations and related activities that are approved under the Mining Act 1978 (Reg ID 72489 and 73946). The Applicant was yet to lodge a Mining Proposal and Mine Closure Plan for the main project at the time of providing advice (5 August 2019) and DMIRS understood this would likely occur once the required tenure is live.

DMIRS noted it had liaised extensively with the Applicant as the project is a DMIRS Lead Agency project and consultation with the DMIRS radiation safety specialists has occurred due to the presence of NORM and the need to manage radioactive material that will be generated by the proposed activity. DMIRS advised that it had provided specific advice during the processes under Part IV of the EP Act, as well as to the Applicant on the recently changed TSF layout to minimise the closure related issues for the proposed facility. In that regard, the Delegated Officer has had regard to DMIRS advice to the EPA in April 2019 (revised TSF layout) and May 2019 (ammonia gas evolution from the Hydromet TSF).

Copies of Radiological Council of W.A. advice to the EPA in November 2018 and April 2019 have noted by the Delegated Officer as the advice applies to this risk assessment.

The shire of Upper Gascoyne did not respond to the direct interest stakeholder referral of the application and there were no public submissions during the 21 day public comment period for the Application.

11. Risk assessment

11.1 Determination of emission, pathway and receptor

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

To establish a Risk Event there must be an emission, a receptor which may be exposed to that emission through an identified actual or likely pathway, and a potential adverse effect to the receptor from exposure to that emission. Where there is no actual or likely pathway and/or no receptor, the emission will be screened out and will not be considered as a Risk Event. In addition, where an emission has an actual or likely pathway and a receptor which may be adversely impacted, but that emission is regulated through other mechanisms such as Part IV of the EP Act, that emission will not be risk assessed further and will be screened out through Table 24 and Table 25.

The identification of the sources, pathways and receptors to determine Risk Events are set out in Table 24 and Table 25 below.

Table 24: Identification of emissions, pathway and receptors during construction

Risk Events						Continue to detailed risk assessment	Reasoning
Sources/Activities		Potential emissions	Potential receptors	Potential pathway	Potential adverse impacts		
Earthworks, construction, mobilisation and positioning of infrastructure	Earthworks, construction of new buildings, plant, infrastructure and vehicle movements	Noise	No residences or other sensitive receptors in proximity	Air / wind dispersion	None expected	No	The premises is sufficiently distanced from noise sensitive premises for the Delegated Officer to infer that construction noise emissions from the premises will not impact on noise sensitive premises.
		Dust			None expected	No	The premises is sufficiently distanced from sensitive receptors for the Delegated Officer to infer that construction dust emissions will not impact on sensitive receptors.

Table 25: Identification of emissions, pathway and receptors during operation and commissioning

Risk Events						Continue to detailed risk assessment	Reasoning
Sources/Activities		Potential emissions	Potential receptors	Potential pathway	Potential adverse impacts		
Cat. 5 – processing and concentrating of REE ores	ROM ore processing into a mixed rare earth carbonate concentrate through the Beneficiation Plant and Hydrometallurgical Plant during normal operation and upset conditions	Fugitive dust (radionuclides)	Nearest dwelling is Gifford Creek Homestead approx.15 km SSW of the plant.	Air / wind dispersion	Flora and fauna impacts from exposure to dust containing low levels of radionuclides	Yes	Refer to Section 11.4
					Human health impacts from exposure to dust containing low levels of radionuclides	No	As noted in EPA Report 1642, potential impacts to human health will be monitored under the Radiation Management Plan (RMP) to ensure that human exposure to radiation is reduced to 'as low as reasonable achievable.' The RMP is required and regulated by the Radiological Council under the Radiation Safety Act 1975 and by DMIRS under the Mines Safety and Inspection Act 1994 and associated regulations which also requires adequate waste management which EPA Report 1642 states has been address by the Applicant in its Radiation Waste Management Plan (RWMP). EPA Report 1642 also notes advice from the Radiation Council that risks associated with radiation can be adequately monitored and managed under the RMP.
		Noise	Nearest noise sensitive receptor is Gifford Creek Homestead approx. 15 km SSW of the plant.		None expected	No	The premises is sufficiently distanced from noise sensitive premises for the Delegated Officer to infer that premises noise emissions will not result in adverse impacts on noise sensitive receptors.
		Point source emissions to air (ABK stack emissions of H_2SO_4, SO_2, HF, PM_{10} and CO)	Nearest dwelling is Gifford Creek Homestead approx. 15 km SSW of the plant.		Public health and/or amenity impacts. Vegetation stress or degradation	Yes	Refer to Section 11.5
		Light	Nearest dwelling is Gifford Creek Homestead approx. 15 km SSW of the plant.	Air dispersion	None expected	No	The premises are sufficiently distanced from sensitive receptors to infer that artificial light emissions during night time periods will not result in adverse impacts on sensitive receptors.

Risk Events						Continue to detailed risk assessment	Reasoning
Sources/Activities		Potential emissions	Potential receptors	Potential pathway	Potential adverse impacts		
		Loss of containment related emissions (e.g. spills, overflows, ruptures) including contaminated stormwater runoff	Surface water, groundwater and soils, vegetation	Direct discharge and infiltration through soils	Impacts to the beneficial use of groundwater (stock water). Impacts to surface water ecosystems. Vegetation smothering and stress.	Yes	Refer to Section 11.6
Cat. 5 - TSFs	TSF surface	Fugitive dust (radionuclides)	Nearest dwelling is Gifford Creek Homestead approx.13 km SSW of the TSFs Surrounding vegetation, surface water systems and wildlife	Air / wind dispersion	Flora and fauna impacts from exposure to dust containing low levels of radionuclides	Yes	Refer to Section 11.4.
					Human health impacts from exposure to dust containing low levels of radionuclides	No	As noted in EPA Report 1642, potential impacts to human health will be monitored under the Radiation Management Plan (RMP) to ensure that human exposure to radiation is reduced to 'as low as reasonable achievable.' The RMP is required and regulated by the Radiological Council under the Radiation Safety Act 1975 and by DMIRS under the Mines Safety and Inspection Act 1994 and associated regulations which also requires adequate waste management which EPA Report 1642 states has been address by the Applicant in its Radiation Waste Management Plan (RWMP). EPA Report 1642 also notes advice from the Radiation Council that risks associated with radiation can be adequately monitored and managed under the RMP.
		NH_3 gas evolution from the Hydromet TSF	Nearest dwelling is Gifford Creek Homestead approx.13 km SSW of the TSFs Surrounding vegetation, surface water systems and wildlife	Air / wind dispersion	Poor ambient air quality Vegetation impacts	No	The Delegated Officer reviewed the NH_3 gas evolution assessments provided by the Applicant as summarised in Section 7.2. Modelling indicated the maximum concentration is of low likelihood to occur and would be dependent on occurrence of worst case pH (greater than pH 10), emission rate and dispersion conditions. The Applicant has further refined the plant design which has lowered worst case pH from 11.3 to below 9. Subject to the Applicant maintaining Hydromet pH conditions below 9, the environment and offsite human receptor risks associated with NH_3 gas evolution are expected to be very low and do not require further detailed assessment. The works approval will include requirements relating to the control of Hydromet TSF pH.
		Hydromet TSF supernatant	Birds	Ingestion and/or contact with Hydromet TSF with elevated pH and low levels of radionuclides	Bird deaths or internal injury	Yes	Refer to Section 11.7
	Pipeline transfer of tailings or return water	Tailings slurry or liquor loss of containment from pipelines	Groundwater aquifers Surface water systems (nearby creeks, tributaries and drains) Surrounding vegetation	Direct discharge	Impacts to the beneficial use of groundwater (stock water). Impacts to surface water ecosystems. Vegetation destruction/ inundation.	Yes	Refer to Section 11.6
	Tailings storage	Seepage - dissolved contaminants, salts, radionuclides, REEs	Groundwater aquifers Surface water systems through superficial aquifer recharge	Direct discharge	Impacts to the beneficial use of groundwater (stock water) Impacts to surface water ecosystems	Yes	Refer to Section 11.8
		Overtopping – release of tailings slurry and/or liquor	Surrounding vegetation Surface water systems (nearby creeks, tributaries and drains) Infiltration of liquor to groundwater	Direct discharge	Impacts to surface water ecosystems Impacts to the beneficial use of groundwater (stock water) Vegetation destruction/ inundation	Yes	Refer to Section 11.9
Cat. 6 - Mine dewatering	Discharge of Frasers and Bald Hills Pits dewater to draining lines	Discharge of abstracted groundwater	Surface water	Direct discharge	Impacts to surface water ecosystem and flow regimes	Yes	Refer to Section 11.10

Risk Events						Continue to detailed risk assessment	Reasoning
Sources/Activities		Potential emissions	Potential receptors	Potential pathway	Potential adverse impacts		
Cat 52: Electrical power generation	Six gas-fired power generators and one diesel-fired generator	Point source emissions to air	Nearest dwelling and noise sensitive receptor is Gifford Creek Homestead approx.15 km SSW of the plant.	Air / wind dispersion	None expected	Yes	Refer to Section 11.7
		Noise			None expected	No	The premises is sufficiently distanced from noise sensitive premises for the Delegated Officer to infer that premises noise emissions (including the generators) will not result in adverse impacts on noise sensitive receptors.
Cat. 64: Class II or III putrescible landfill site	Class II putrescible landfill bunker, inert landfill bunker and a waste depot	Gaseous emissions and odour	Nearest dwelling is Gifford Creek Homestead approx.15 km SSW of the plant.	Air / wind dispersion	None expected	No	The landfill bunkers are sufficiently distanced from sensitive receptors to infer that fugitive gaseous emissions and odour impacts on sensitive receptors are not expected.
		Fugitive dust			None expected	No	The landfill bunkers are sufficiently distanced from sensitive receptors to infer that fugitive dust impacts on sensitive receptors are not expected.
		Leachate seepage	Groundwater aquifers Surface water systems through superficial aquifer recharge	Direct discharge	Impacts to the beneficial use of groundwater (stock water)	Yes	Refer to Section 11.11
		Contaminated stormwater runoff			Impacts to surface water ecosystems Impacts to the beneficial use of groundwater (stock water)	Yes	Refer to Section 11.11
Cat. 73: Bulk storage etc. of chemicals	Storage of fuel and chemicals	Loss of containment including via transfer pipelines, equipment failure (e.g. pumps) and tank overflows.	Groundwater aquifers Surface water systems (nearby creeks, tributaries and drains) Surrounding vegetation	Direct discharge	Impacts to the beneficial use of groundwater (stock water). Impacts to surface water ecosystems. Vegetation smothering and stress.	Yes	Refer to Section11.6
Cat. 85: Sewage facility	Treatment of sewage from the ore processing facility	Odour	Nearest dwelling is Gifford Creek Homestead approx.15 km SSW of the plant.	Air / wind dispersion	None expected	No	The sewage facility is small-scale and the premises are sufficiently distanced from sensitive receptors to infer that odour from the sewage facility is unlikely to be detectable beyond the immediate area of the sewage facility and will not result in adverse impacts on sensitive receptors.
		Loss of containment	Surrounding vegetation Surface water systems (nearby creeks, tributaries and drains) Infiltration of liquor to groundwater	Direct discharge	Impacts to the beneficial use of groundwater (stock water). Impacts to surface water ecosystems. Vegetation smothering and stress.	Yes	Refer to Section 11.6.
	Sprayfield irrigation of treated sewage	Treated sewage discharge to land	Soil and infiltrating to groundwater aquifers Surface water systems through superficial aquifer recharge	Direct discharge	Soil contamination Impacts to the beneficial use of groundwater Surface water ecosystem impacts	Yes	Refer to Section 11.12.

11.2 Consequence and likelihood of risk events

A risk rating will be determined for risk events in accordance with the risk rating matrix set out in Table 26 below.

Table 26: Risk rating matrix

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

DWER will undertake an assessment of the consequence and likelihood of the Risk Event in accordance with Table 27 below.

Table 27: Risk criteria table

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

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

* In applying public health criteria, DWER may have regard to the Department of Health's *Health Risk Assessment (Scoping) Guidelines*.

"onsite**"** means within the Prescribed Premises boundary.

11.3 Acceptability and treatment of Risk Event

DWER will determine the acceptability and treatment of Risk Events in accordance with the Risk treatment Table 28 below:

Table 28: Risk treatment table

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

11.4 Risk Assessment – TSF and ore processing facility fugitive dust emissions containing radionuclides

11.4.1 Description of risk event

Fugitive dust containing radionuclides from the ROM pad at the ore processing facility or from drying tailings on the surface of the Hydromet TSF becomes airborne impacting on flora and fauna.

11.4.2 Identification and general characterisation of emission

The ore contains REE bearing mineral phosphate monazite which contains low levels of thorium and uranium and their decay progeny as NORM. As stated in EPA Report 1642, the ore has evaluated levels of radiation of 0.9 μSv/h which is concentrated through the waste stream at processing and through to the tailings in the TSF. Dust generated from the ROM pad at the ore processing plant or from TSFs will have low levels of radionuclides. Ore is delivered to the ROM pad via trucks from the mine areas, stockpiled and then reclaimed and fed into the ore processing plant crusher feed bin using a front end loader.

As established in the Section 8 characterisation of tailings, the Beneficiation TSF is defined as non-radioactive with an average radionuclide concentration of approximately 0.8 Bq/g. It is therefore not further considered in this risk assessment. The Hydromet TSF is defined as radioactive with an average radionuclide concentration of 33 Bq/g.

Hydromet TSF tailings are combined with spent liquor and discharged in layers, however dust lift off from the Hydromet TSF can occur in the event of drying tailings beaches that may develop in the time between layer applications.

In EPA Report 1642, the assessment of flora and vegetation notes that an assessment was undertaken using the Environmental Risk from Ionising Contaminants Assessments (ERICA) software to model the radiation exposure risk to flora and fauna. The model predicted that the exposure of organisms would be below the threshold dose rate, and that the external gamma dose rate on the surface post-closure would be similar to background levels.

11.4.3 Description of potential adverse impact from the emission

Trace concentrations of radionuclides in dust resulting in impacts to flora, fauna, soil and surface water ecosystems.

11.4.4 Criteria for assessment

The Applicant's RWMP provides trigger values that are based on authorised limits and/or baseline values and takes account of those identified in NORM Guideline 6 Reporting Requirements (DMP, 2010d).

11.4.5 Applicant controls

ROM Pad dust controls

The Application states that dust from the ROM pad will be managed through:

- Sprinklers systems on ROM pad stockpiles;
- Covers; and
- Water sprays using a water cart.

Hydromet TSF dust controls

The Application outlines the following related to control of dust generation from the Hydromet TSF and impacts from radionuclides (GHD 2019):

- Continuous containment embankments elevated above the tailings surface break up wind flow and trap particulates within the storage;
- Strong inter-particle forces due to the extremely fine grain size and cohesive nature of the tailings;
- Maintaining damp moisture conditions at the surface of tailings by frequent discharge of layers in the Beneficiation TSF and by combining spent liquor with tailings in the Hydromet TSF;
- If dry surface conditions develop between tailings layer applications, Beneficiation TSF decant water will be used to irrigate dry areas. Water will be applied using a low-ground pressure (LGP) water cart developed to traffic on dry area of the TSF; and
- Use of dust suppressant chemicals using the LGP water cart as a contingency for dust suppression in the event of prolonged dry conditions such as plant breakdown or temporary shutdown.

Monitoring of ambient air quality and radionuclides in dust will be undertaken as part of the Premises' commitments under their Radiation Management Plan and Radioactive Waste Management Plans. Dust deposition gauges and high volume samplers will collect dust samples at pre-determined locations for composite analysis on an annual basis and rotate between approved off-site locations, respectively.

Monitoring of controls for containment of radioactive waste are stated in the Application to include:

- Weekly visual inspection of surface water management structures such as bunds, drainage channels, tailings and water pipelines;
- Weekly inspection of TSFs for erosion or signs of compromise to the integrity of their structure, including signs of seepage of tailings or water from tailings into the environment immediately surrounding the TSFs; and
- Inspections of management controls following major rainfall or extreme weather events.

11.4.6 Consequence

Dust lift off from the ROM pad or Hydromet TSF may contain low levels of radionuclides. Dust lift off events are expected to be infrequent, sporadic and short-term events coinciding with strong wind conditions. Dust containing low levels of radionuclides would have low level local scale impacts. Therefore, the Delegated Officer considers the consequence to be **moderate**.

11.4.7 Likelihood of Risk Event

Taking into consideration the concentrations of radionuclides and the Applicant's proposed operational controls and monitoring, radionuclide impacts to flora, fauna, soil or surface water from the ROM pad or Hydromet TSF dust lift off will probably not occur in most circumstances. Therefore the Delegated Officer considers the likelihood of impacts from dust containing radionuclides from the ROM pad or Hydromet TSF to be **unlikely**.

11.4.8 Overall rating of TSF and ore processing facility fugitive dust emissions containing radionuclides

The Delegated Officer has determined that the overall rating for the risk of impacts to flora, fauna, soil or surface water from ROM pad or Hydromet TSF dust lift off to be **Medium**.

11.5 Risk Assessment – Point source emissions to air

11.5.1 Description of risk event

Point source emissions to air from the ore processing facility cause a health or vegetation impact.

11.5.2 Identification and general characterisation of emission

Emissions to air will be emitted from:

- ABK Normal Scrubber Stack or Emergency Scrubber Stack;
- Power plant stacks; and
- MREC dryer stacks.

The ABK is fed by an acid-concentrate slurry (mixture of MREC and H_2SO_4 that reacts) and sulfuric acid evaporated and decomposed in sulfur trioxide and sulfur dioxide. Emissions from the ABK include SO_2, $H2_SO_4$, HF, CO and PM_{10} which were the subject of further Applicant investigation through air dispersion modelling in ERM 2018 and then revised in ERM 2019 as summarised in section 7.

The Applicant Modelled air emission scenarios in ERM 2019 were:

- Normal operations – ABK off-gases treated through the normal scrubbing system and emitted via the Normal Scrubber Stack.
- Start-up operations – ABK is brought online to operating temperature with off gases likely to be similar to normal operations. Off-gases treated through the normal scrubbing system and emitted via the Normal Scrubber Stack
- Upset conditions – these include scenarios such as:
    - the ABK being operated at low fire mode accidently during normal operations where kiln feed is turned off and gases are diluted with bleed air. Off-gases are treated through the normal scrubbing system with the WESP on and emitted via the Normal Scrubber Stack. Expected to occur 2-3 times per year;
    - an unplanned ABK shutdown when the kiln burner is tripped where feed to the kiln is stopped and gases are diluted with bleed air. Off-gases are treated through the normal scrubbing system with the main gas scrubber with WESP off and emitted via

the Normal Scrubber Stack. Expected to occur 2-3 times per year.

- Emergency operations – scenarios such as interruption of power supply or failure of the main gas scrubbing system. The kiln feed and burner will be tripped whilst off-gas within emissions from ABK will be diluted with bleed air. Off-gases from the kiln are redirected to a separate emergency scrubbing system and emitted via the Emergency Scrubber Stack. The emergency scrubbing system provides short-term treatment during an emergency event while the ABK is taken offline and cools. Prior to re-starting the ABK, the caustic scrubbing water in the system is replaced in readiness for the next emergency event.

Emissions to air can vary under different scenarios and plant operating conditions, however emissions from the ABK are not expected to significantly vary as depicted in Appendix 4, Part B which shows the model input stack concentrations and emission rates used by the Applicant. The most significant variation is an increase in H_2SO_4 emission rates during an emergency event.

Table 29 shows the discrete receptor maximum ground level concentrations in comparison to assessment criteria. The information in Table 29 can be view in combination with the excerpt of summary findings from ERM 2019 as provided in Appendix 4, Part C. In general, ground level concentrations are well below assessment criteria under all scenarios. ERM 2019 noted that excluding background maximum concentrations predicted are approximately 0.04% of the criteria. Short-term increases in H_2SO_4 are also evident during upset and emergency conditions, albeit less than 50% of the assessment criteria.

Table 29: Maximum ground level concentration at receptors and comparison to assessment criteria

Pollutant	Averaging period	Criteria (µg/m³)	Normal		Start-up		Upset – WESP on		Upset – WESP off		Emergency	
			Max. GCL (µg/m³)	%	Max. GCL (µg/m³)	%	Max. GCL (µg/m³)	%	Max. GCL (µg/m³)	%	Max. GCL (µg/m³)	%
H_2SO_4	3-min	33	0.6	1.82	0.5	1.52	0.5	1.52	14.9	45	14.9	45
	1-hr	18	0.2	1.11	0.1	0.56	0.1	0.56	4.5	25	4.5	25
SO_2	10-min	712	5.6	0.79	4.3	0.60	4.3	0.60	1.2	0.17	1.2	0.17
	1-hr	196	2.7	1.38	2.1	1.07	2.1	1.07	0.6	0.31	0.6	0.31
	24-hr	52	0.6	1.15	0.4	0.77	0.4	0.77	0.1	0.19	0.1	0.19
HF	24-hr	2.9	0.04	1.38	0.03	1.03	0.03	1.03	0.03	1.03	0.03	1.03
PM_{10}	24-hr	50	19.1	38	19.1	38	19.1	38	n/a	n/a	n/a	n/a
	Annual	25	17	68	17	68	17	68	n/a	n/a	n/a	n/a
CO	8-hr	10,300	17.9	0.17	19.7	0.19	19.7	0.19	19.7	0.19	17.6	0.17

The power plant consists of unattended modular genset units consisting of six gas-fired and one diesel black start units each with an air emissions exhaust stack. The power station will have NOx emissions less than 190 mg/Nm^3 (15% O_2). There will be two dryers installed for drying the flotation concentration and mixed rare earth carbonate product. The dust in off-gases from the drying process will be treated via baghouse or venturi scrubbers.

11.5.3 Description of potential adverse impact from the emission

SO_2 is a colourless, irritating and reactive gas with a strong odour which can result in respiratory problems as a result of short-term exposure at increased levels. High levels of CO may affect the amount of oxygen carried in the blood stream, and is generally more related to exposure to high concentrations in enclosed or low ventilation spaces. Sulfuric acid mists are corrosive and respiratory irritants. Hydrogen fluoride is also corrosive and irritant, can dissolve in water bodies, and attach itself to particulate matter and settle onto soil or plant life causing harm. Smaller size particulate matter such as PM_{10} poses a greater risk of being drawn deep into the lungs with most severe impacts being reduced life expectancy due to long-term exposures.

The site is located in a remote area and distant from nearby receptors, the Gifford Creek Homestead and Edmund Homestead which are 15 km and 24 km from the ore processing facility respectively. There is native vegetation within and surrounding the premises.

11.5.4 Criteria for assessment

The ambient air criteria adopted by the Applicant are shown in Table 30 below as taken directly from ERM 2019. These are accepted as relevant and applicable criteria for the purposes of this assessment.

Table 30: Ambient air criteria (source: ERM 2019)

Pollutant	Averaging Period	Value[1] (µg/m^3)	Source	EU [4] (µg/m^3)	WHO [3] (µg/m^3)
	Adopted			*For comparison only*	
Sulfuric Acid (H_2SO_4)	3-minute	33	Class 2 Pollutant – toxicity based Victoria Government Gazette 2001	-	-
	1-hour	18	NSW EPA (NSW EPA, 2017)	-	-
Sulfur dioxide (SO_2)	10-minute	712	NSW EPA (NSW EPA, 2017)	-	500

Pollutant	Averaging Period	Value[1] (µg/m³)	Source	EU [4] (µg/m³)	WHO [3] (µg/m³)
	Adopted			For comparison only	
	1-hour	262 (196)[2]	Varied NEPM (NEPM, 2019)	350	-
	24-hour	52	Varied NEPM (NEPM, 2019)	125	20
Hydrogen Fluoride (HF)	24-hour	2.9	DWER draft air quality guideline for general vegetation (Email from DWER dated 19 July 2019)	-	-
Particulate matter with aerodynamic size less than 10µm (PM_{10})	24-hour	50	Varied NEPM (NEPM, 2019)	50	50
	Annual	25	Varied NEPM (NEPM, 2019)	20	20
Nitrogen dioxide (NO_2)	1-hour	169 (150)[2]	Varied NEPM (NEPM, 2019)	200	200
	Annual	36 (28)[2]	Varied NEPM (NEPM, 2019)	40	40
Carbon Monoxide (CO)	8-hour	10,300	Varied NEPM (NEPM, 2019)	10,300	10,300

Note:
1. Values at 25ºC and 101.3kPa
2. Standards applicable from 2025
3. WHO (2005)
4. WHO (2006)

11.5.5 Applicant controls

The main source of ore processing plant air emissions is the ABK where off gases are emitted via the Normal Scrubber Stack or Emergency Scrubber Stack. Off gases emitted via either stack are treated by a scrubbing plant process train as depicted in Figure 16 in Appendix 3.

Table 31: Applicant controls for ABK emissions to air.

Control type	Description

Infrastructure / design	**ABK Normal Scrubber System and stack**
	• Emissions via a 35 m normal scrubber stack
	• Normal Scrubber System consisting of:
	  o low pressure drop fixed throat venturi scrubber;
	  o medium pressure drop fixed throat venturi scrubber;
	  o chevron-type entrainment separator;
	  o WESP;
	  o Dual alkali scrubber consisting of counter current packed tower scrubber system and an alkali regeneration system;
	  o Duty/standby main ID fan.
	• Air emission design criteria limits of:
	  o H_2SO_4 / SO_3 (as SO_3 equivalent) - < 45 mg/Nm³
	  o SO_2 - < 280 ppm

Control type	Description
	○ HF - <50 mg/Nm^3 ○ Total suspended particulates - < 200 mg/Nm^3 ○ PM_{10} - <10 mg/Nm^3 • CEMS for particulate matter, SO_2, CO, HF and SO_3 compliant with EN14181 – Stationary Source Emissions Quality Assurance of Automated Monitoring Systems.
	Emergency Scrubber System and stack • Emissions via a 35 m emergency scrubber stack • Emergency Scrubber Stack: ○ Counter current emergency packed tower scrubber with fixed throat venturi scrubber on the gas inlet; ○ Candle-type emergency fibre bed mist eliminator vessel; • Duty/standby main ID fan
Management / procedures	• Initial stack sampling for comparison to CEMS. • Commissioning emissions managed in the same manner as process upset conditions and process variability. • Event-based triggering of the emergency treatment system.

Dryers installed for drying the flotation concentration and mixed rare earth carbonate product will be fitted with a baghouse or venturi scrubbers.

11.5.6 Consequence

Ground level concentration criteria at receptors are likely to be met based on review of the Applicant's air emissions impacts assessment and the above information including the Applicant's proposed controls. The Delegated Officers considers the consequence of air emission impacts from the Rare Earths Facility to be **minor**.

11.5.7 Likelihood of Risk Event

If the Applicant implements the air emissions controls as proposed, the Delegated Officer considers that impacts from air emissions are unlikely to occur in most circumstances, therefore the likelihood is **unlikely**.

11.5.8 Overall rating of point source emissions to air

The Delegated Officer has compared the consequence and likelihood ratings described above with the risk rating matrix (Table 26) and determined that the overall rating for the risk of emissions to air is **medium.**

11.6 Risk Assessment – Loss of containment and contaminated stormwater discharges (ore processing facility and pipelines)

11.6.1 Description of risk event

Soil contamination, groundwater contamination or impacts to surface water through ore processing facility release of process reagents, chemicals and liquors onto the ground within the processing plant. Pipelines between the ore processing facility and TSFs rupture and release tailings slurry or decant to ground or into surface water.

11.6.2 Identification and general characterisation of emission

Hydromet Plant slurry and liquor is circum neutral (pH expected between 6.6 and 7) and saline with elevated REEs, magnesium, ammonia, sulfur, sulfate, molybdenum, fluoride concentrations and low concentrations of radionuclides (uranium and thorium). Beneficiation Plant slurry and liquor are alkaline (solids pH 10.1 and liquids pH 11.8 approximately) and saline with elevated REEs, fluoride and molybdenum and very low levels of radionuclides.

Diesel, RE-60 and Rinkalore F410 fall within category 73 and are stored within contained bunded areas. However, there is the potential for spillages of contaminated stormwater discharges to land.

Pipelines transfer tailings from the Beneficiation Plant and Hydromet Plant to the Beneficiation TSF and Hydromet TSF respectively. Tailings decant from the Beneficiation TSF is pumped back to the ore processing facility for reuse. A drainage line crossing separates the TSFs from the ore processing facility.

Stormwater runoff may be cross contaminated through contact with spilt materials or contaminated soils.

11.6.3 Description of potential adverse impact from the emission

Stormwater runoff within the ore processing plant area and diesel storage is directed to sedimentation ponds via open gravity swale drains. Both the ponds and swale drains are unlined, therefore stormwater contaminated from contact with process slurries or liquors has the potential to infiltrate and contaminate localised groundwater. Similarly in the event of the release of process slurry or liquor onto unbunded ground in the ore processing plant area.

The release of slurry and liquors will mostly be captured within unlined pipeline corridors which direct material to unlined spillage ponds at low points. A release from a portion of pipeline traversing a river crossing will result in direct discharge of slurry or liquors to surface water with likely impacts to the ecosystem through sedimentation and water quality impacts.

11.6.4 Criteria for assessment

ANZECC 2000 livestock drinking water guidelines (groundwater) and ANZECC 2018 guidelines for protection of freshwater ecosystems (surface water).

11.6.5 Applicant controls

Ore processing facility

- Equipment located over concrete slabs with bunding that will contain spillage of process slurries and liquors.
- Tanks containing process slurries and/or liquors are located within concrete bunds sized to capture 110% of the volume of the largest tank.
- Tanks containing reagents classed as dangerous goods are bunded in accordance with the *Dangerous Goods Safety (Storage and Handling of Non-explosives) Regulations* and Australian Standard AS 3780.
- Infrastructure and piping inspected on a daily basis.
- Spill Response Procedure related to spill containment, clean up and disposal.
- Stormwater runoff directed to the sedimentation pond via open gravity swale drains. The sedimentation pond will be designed for runoff from the 5 day 85 percentile rainfall event (i.e. 23.5 mm rainfall) without discharge in accordance with the *Best Practice Erosion and Sediment Control* (International Erosion Control Association Australasia 2008).
- A secondary control measure to direct residual spill material from piping over unsealed ground and overflow from concrete bunds to the plant site sedimentation pond via open gravity swale drains. The sedimentation pond and swale drains are unlined but allow removal of contaminated soils/surface water and disposal in a controlled manner into the lined Hydromet TSF.

Bulk chemical storage

- Self-bunded diesel tank and heavy duty spill grates in the refueling bay connected to an adjacent drainage sediment pond for water collection.
- RE-60 on trucks within an apron area contained within a kerb and a slope that falls back into

the storage tank bund. Spillage within the apron area can be hosed into the bunded area and bunded area spillage is pumped to Effluent Treatment section of the ore processing facility.

- Rinkalore F410 stored on dual IBC spill pallets within the Bulk Reagent Storage area.
- Separation of uncontaminated stormwater from ore processing plant areas through intercepting surface water runoff using bunding and open vee drains with culverts beneath roads.

Pipelines

- Tailings and return water pipelines (RWPs) are HDPE.
- Tailings lines are installed in a bunded piping corridor to contain any spillage.
- Spillage ponds are provided at low points.
- Inspections to detect leaks and tailings line pressure continuously monitored with alarms for high pressure.
- A slurry pipeline located at the higher end of the catchment will traverse a river crossing. Any potential breaches and direct discharge spills into the rover at the crossing area will be addressed by an elevated pipe bridge and double sleeved pipes in this area only.
- The remainder of the route will have bunded corridors to direct spillage to spillage containment ponds or into the TSFs.
- Spillage containment ponds are designed for 12 hours of flow from the largest pipe and are unlined.

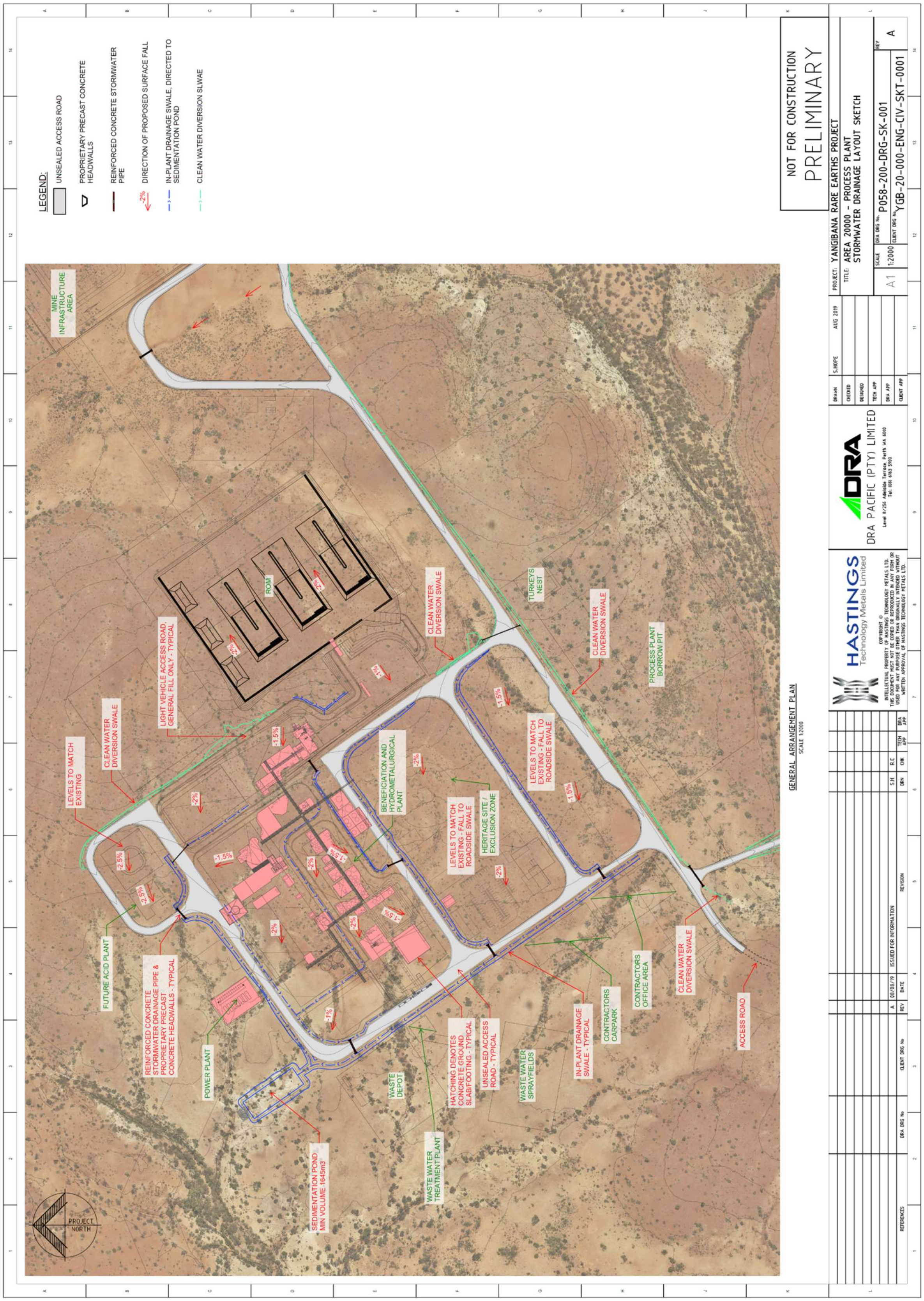


Figure 15: Ore Processing Plant stormwater drainage plan

11.6.6 Consequence

If an ore processing facility (including chemical storage) or pipeline spill to ground or bund overflow occurs, then the Delegated Officer has determined that the impact of release of process slurries, liquors or chemicals will be low level, on site impact. The consequence would be **minor**.

If a pipeline spill to surface water occurs, then the Delegated Officer has determined that the impact of release of process slurries or liquors will be mid-level, offsite impacts, local scale. The consequence would be **major**.

11.6.7 Likelihood of Risk Event

Taking into consideration the Applicant controls, the likelihood of process slurry and liquors discharging to ground resulting in groundwater contamination impacting its beneficial use is **unlikely**.

Taking into consideration the Applicant controls, the likelihood of process slurry and liquors discharging to surface water and impacting on the surface water ecosystem is also **unlikely**.

11.6.8 Overall rating of loss of containment and contaminated stormwater discharges

The Delegated Officer has compared the consequence and likelihood ratings described above with the risk rating matrix (Table 26) and determined that the overall rating for the risk process slurries and liquors discharging onto the ground and into surface water is **Medium**.

11.7 Risk Assessment – Birds ingesting / contacting TSF supernatant

11.7.1 Description of risk event

Birds attracted to the TSFs may come into contact or ingest alkaline and saline tailings/decant with trace radionuclides causing soft tissue damage or bird deaths.

11.7.2 Identification and general characterisation of emission

The Hydromet Plant slurries and liquors are circum-neutral (pH expected between 6.6 and 7) and saline with elevated concentrations of REEs, magnesium, ammonia, sulfur, sulfate, molybdenum, fluoride and low concentrations of radionuclides (uranium and thorium). Beneficiation Plant slurries and liquors are alkaline (solids pH 10.1 and liquids pH 11.8) and saline with elevated REEs, fluoride and molybdenum concentrations and very low concentrations of radionuclides.

The TSFs are not in proximity to known surface water body breeding sites, however there are adjacent surface waters (ephemeral creeks, drainage lines). It is possible that birds will be attracted to the TSFs, however this is yet to be determined.

11.7.3 Description of potential adverse impact from the emission

Alkaline supernatant may damage the soft tissues of birds that either ingest tailings liquor (supernatant) or land within supernatant ponds. Documented evidence has demonstrated that acidic tailings result in bird deaths and soft tissue injuries (Donato 2017) and it is thought that alkaline tailings may cause similar impacts.

11.7.4 Criteria for assessment

None specified.

11.7.5 Applicant controls

The hydromet tailings alkalinity is controlled and expected to be pH 6.6 to 7, partly to reduce the risk of ammonia gas generation that may occur at high pHs.

11.7.6 Consequence

The consequence of bird contact with beneficiation tailings is considered moderate (mid-level on-site impact) due to the potential for acute impacts with alkaline tailings.

The consequence of bird contact with hydromet tailings is considered moderate (mid-level on-site impact) due to the elevated radionuclides concentration of the tailings.

11.7.7 Likelihood of Risk Event

The likelihood of birds being impacted from contact with beneficiation tailings is considered possible. A preliminary likelihood of impact from birds contacting with hydromet tailings is possible.

11.7.8 Overall rating of TSF bird impacts

The Delegated Officer has compared the consequence and likelihood ratings described above with the risk rating matrix (Table 26) and determined that a preliminary risk rating for impacts to birds from contact or ingestion of TSF supernatant is **Medium** for both hydromet tailings and beneficiation tailings. It is noted that the data to support the risk rating is not available at this time and this rating may change, pending data obtained during operations.

11.8 Risk Assessment – TSF Seepage

11.8.1 Description of risk event

Seepage from tailings stored in the TSFs impacts on groundwater levels, quality and beneficial use of the superficial aquifer underlying the TSFs or impacts on surface water ecosystems through groundwater recharge.

11.8.2 Identification and general characterisation of emission

The Applicant undertook seepage modelling as summarised in Section 8.4. For the proposed TSF layout, modelling in GHD 2019 was limited to the Beneficiation TSF as the Hydromet TSF includes a geocomposite liner system that is expected to ensure very small rates of seepage, negating the need for seepage modelling.

Potential environmental harmful species contained in the tailings solids (including radionuclides) identified in GHD 2019 are fixed or immobile, therefore it states the risk of adverse environmental effects associated with seepage is primarily governed by the seepage of transport water. Dissolved materials in the tailings process liquor at concentrations above NEPM or ANZECC guideline values and/or local groundwater concentrations are:

- Beneficiation TSF – fluoride, molybdenum and pH
- Hydromet TSF – fluoride and magnesium sulphate

It is also noted that REEs are expected to be contaminants of interest for both TSFs.

GHD 2019 found that for the expected life of the facility seepage from the Beneficiation TSF is expected to remain within the TSF footprint with the majority of ponding expected in the highly weathered to moderately weathered granite. The likelihood of significant downward seepage of water contained in saturated, very low permeability tailings stored at the ground surface was considered very low.

Beneficiation TSF filtrate results reflected the conditions expected in the combined beneficiation liquid and reported a pH of 11.8 and an electrical conductivity (EC) of 5220 us/cm.

Other results included:

- Chloride at 285 mg/L - no ANZECC 2000 livestock or NEPM 2013 guidelines;
- Sulfate at 182 mg/L - less than the ANZECC 2000 livestock and NEPM 2013 guidelines of 1000 and 5000 mg/L respectively;
- Fluoride at 2.6 mg/L - exceeded the ANZECC 2000 livestock guideline of 2 mg/L and NEPM 2013 drinking water guideline of 1.5 mg/L. The Applicant’s static test work indicated that fluoride concentrations diminish with flushing, however this is not considered indicative of the operating TSF which will have continual tailings deposition during operations;
- Total dissolved solids (TDS) at 3390 mg/L – less than the ANZECC 2000 upper range for livestock of 5000 mg/L, however an increase over background of TDS at 600 – 2800 mg/L.
- Alkalinity tests found the majority source was hydroxide at 703 mg/L followed by carbonate at 213 mg/L with bicarbonate at detection limit.

Significant seepage into underlying groundwater has the potential to contaminate downstream surface water receptors including Frasers Creek. The 2D seepage modelling indicates however that seepage will be retained within the highly weathered/ moderately weathered granite zone under the Beneficiation TSF and it is unlikely to be transported outside of the TSF footprint (GHD 2019). The highly weathered/moderately weathered granite is underlain by less permeable slightly weathered granite layer. The modelling also anticipates that the seepage flux will dissipate within a 100 year time period (GHD 2019).

11.8.3 Description of potential adverse impact from the emission

Adjacent sensitive receptors are stygofauna in surficial alluvial groundwater aquifers present at the site and macroinvertebrate fauna resident in the hyporheic zones of the adjacent ephemeral tributaries of Frasers Creek.

Fluoride and molybdenum levels in the Beneficiation TSF pore water are expected to be elevated above ANZECC (2000) livestock drinking water guidelines, however seepage of pore water is expected to be contained within the TSF footprint and livestock will not have access to water.

11.8.4 Criteria for assessment

ANZECC (2018) toxicant default guideline values for protection of freshwater aquatic ecosystems and ANZECC (2000) livestock drinking water guidelines.

11.8.5 Applicant controls

Beneficiation TSF

- Located in an area with low permeability in the superficial soils and near surface weathered rock (<2 x 10^{-7} m/s) and low permeability in the deeper, slightly weathered granite rock mass (<1 x 10^{-8} m/s) as indicated by the Applicant's in-situ permeability tests.
- Minimum 300 mm of clayey in-situ soils at the base of the pond impoundment area will be proof compacted during construction to reduce potential for vertical seepage following significant rainfall events
- Construction materials sourced onsite with materials for low permeability zones within embankments from external borrow areas (but from the TSF footprint where possible).
- Constructed embankment – near surface clayey sand deposits (i.e. saprolite material) will be used to construct the low permeability embankment zones and backfill to cut of trenches.
- Detailed design will include the following contingency measures:
    - Treatment of any identified preferential seepage paths between the TSF and downstream receptors using barrier systems such as cement grouting or cut-off walls;
    - Contingency seepage interception systems such as trenches or recovery bores; and
    - Geosynthetic lining of collection drains within the final TSF landform to further reduce long term seepage rates.
- Perimeter discharges which mitigates liquor ponding by the embankment.
- Maintaining unsaturated beaches and a small central decant pond.

Hydromet TSF

- Geocomposite lining system comprising 300mm thick compacted clay liner below a HDPE liner. The Applicant supplied an example geosynthetic liner specification (Appendix H in GHD 2019) which includes generic installation and testing procedures.
- HDPE design characteristics (i.e. white membrane, selection of additives) appropriate to the site environment.
- Quality assurance / quality control procedure detailing construction and installation process and including seam testing, destructive testing of liner samples and electrical leak testing post-installation.
- Contingency option for leachate trickle systems to increase evaporative loss of decant water whilst simultaneously cooling the exposed portion of the liner.

TSF Monitoring / Inspection

- Monitoring program to be implemented to evaluate performance of the TSFs against the original design expectations, comprising six groundwater monitoring bores and three vibrating wire piezometers (VWPs) as summarised in Table 32.

Table 32: Summary of Applicant seepage related TSF monitoring

Applicant monitoring item	Applicant monitoring schedule	Details
Groundwater bore	• Monthly, 12 months prior to TSFs operations, then • Quarterly throughout life of project	• Approximately 70m deep to intercept groundwater in the confined aquifer • Nested bore at 20m to validate that upward seepage from the confined aquifer is not occurring.
Vibrating wire piezometers	• Monthly from the time of installation throughout life of project	• Installed under the embankments to identify seepage development within the underlying foundation.

- Additional monitoring of a downstream pastoral bore (i.e. Frasers Well as shown in Figure 9) and the nearest permanent pond downstream in the Lyons River will be sampled and analysed for water quality on a quarterly basis as shown in Table 33.

Table 33: Applicant proposed TSF monitoring parameters

Parameter	Units
Standing Water Level (SWL)	Mbgl
Total Suspended Solids	mg/L
Total Dissolved Solids	mg/L
Electrical conductivity	µS/cm
Radium Activity – Radium 226 and Radium 228	Bq/L
Dissolved Major Cations – Calcium, Magnesium, Sodium, Potassium	mg/L
Dissolved Metals- Aluminium, Antimony, Molybdenum, Strontium, Thorium, Uranium, Iron	mg/L
Total metals: Aluminium, Arsenic, Boron, Barium, Beryllium, Cadmium, Cobalt, Chromium, Copper, Manganese, Nickel, Lead, Selenium, Vanadium, Zinc, Iron	mg/L
Total Recoverable Mercury: Mercury	mg/L

- Proposed trigger levels for groundwater quality within the TSF area for early detection of seepage impacts:
  - Exceedance of >25% beyond natural variability on 3 consecutive samples; and
  - Exceedance of ANZECC 2000 livestock drinking water guidelines and NEPM drinking water quality for elements that are not exceeded naturally.
- Proposed trigger level exceedance actions including investigation to determine possible causes of elevated levels including comprehensive water analyses, determination of any

additional management, amelioration or monitoring.

- Daily (two times for production shift) operational inspections of tailings and water management with monthly inspections of safety and environment.

11.8.6 Consequence

If seepage alters groundwater quality such that it impacts on livestock drinking water quality, then the impact is considered to be a mid level impact to an offsite receptor. However, seepage from the Beneficiation TSF is expected to remain within the TSF footprint, contingency measures form part of the design scope and livestock will not have access to this water and there is a very low likelihood of downward seepage. Seepage would have a minimal localised impact on livestock drinking water quality. The consequence of Beneficiation TSF seepage affecting livestock drinking water quality is therefore **minor**.

The consequence of impacting on the hyporheic ecosystem in the drainage line adjacent to the Beneficiation TSF is potentially a mid level impact to an onsite receptor, therefore **moderate.** Given the abundance and diversity of microinvertebrate species is not known at present, this consequence is considered preliminary, in consideration to the expectation that seepage should remain within the TSF footprint.

The assumed very low rates of seepage from the Hydromet TSF are subject to installation of a geocomposite lining system that is fit for purpose and free from faults or damage and remains free of significant faults or damage during its life expectancy. Seepage or leakage will result in elevated concentrations of MgO_4 salts infiltrating to groundwater. The consequence of Hydromet TSF seepage affecting adjacent hyporheic ecosystems or livestock drinking water quality is therefore **moderate**.

11.8.7 Likelihood of Risk Event

Seepage from the Beneficiation TSF is expected to remain within the TSF footprint, contingency measures form part of the design scope, livestock will not have access to this water and there is a very low likelihood of downward seepage. The likelihood of Beneficiation TSF seepage impacting on surrounding livestock drinking water is **rare**.

Given the closer location of the drainage line, the preliminary likelihood of impacting on the hyporheic ecosystem within the on-site drainage line is considered **unlikely** given the use of a clay liner and presence of underlying granite.

The Applicant has proposed a geocomposite lining system for the Hydromet TSF to be installed and tested according to QA/QC procedures along with ongoing operational controls including monitoring and management. The likelihood of Hydromet TSF seepage impacting on surrounding livestock drinking water is **unlikely**.

11.8.8 Overall rating of TSF seepage

The Delegated Officer has compared the consequence and likelihood ratings described above with the risk rating matrix (Table 26) and determined that the overall rating for the risk of livestock drinking water impacts from Beneficiation TSF and Hydromet TSF seepage is **Low** and **Medium** respectively.

The preliminary risk rating for the Beneficiation TSF impacting on the hyporheic ecosystem in the adjacent drainage line is considered **Medium.**

11.9 Risk Assessment – TSF overflow

11.9.1 Description of risk event

Tailings slurry and/or supernatant are released from one or both of the TSFs resulting in damage to surrounding vegetation, impacts on surface water ecosystems or impacts on the beneficial use of groundwater.

11.9.2 Identification and general characterisation of emission

Beneficiation TSF tailings solids are unlikely to leach any significant concentrations of elements and are classified as non-radioactive. The supernatant will contain fluoride (2.6 mg/L) and molybdenum (2.5 mg/L) above ANZECC 2000 livestock drinking water guidelines and is alkaline (expected pH 11.1). Other Beneficiation TSF filtrate characteristics are summarised in Section 11.8.2.

Hydromet TSF supernatant will be circum neutral (pH 6.6 to 7) with elevated concentrations of $MgSO_4$ salts (Mg 5,957 mg/L; SO_4 27,066 mg/L) and also ammonia, sulfur, molybdenum and fluoride. REEs are also expected but the concentrations are currently unknown. The Hydromet tailings are also classified as radioactive, however the activity remains primarily with the solids; radionuclide concentrations in pore water were found to be generally low, with the majority of samples recording concentrations/ radioactivity below minimum detection limits and at similar levels to those in regional pastoral bores.

Both TSFs are designed with spillways where the Hydromet TSF spills into the Beneficiation TSF initially, prior to discharging from the Beneficiation TSF spillway.

11.9.3 Description of potential adverse impact from the emission

Alkaline, saline supernatant may impact on vegetation health, through inundation of vegetation root systems or direct impact to leaves//plants. Release of trace radionuclides and metals/metalloids in solution will result in localised soil contamination, groundwater contamination and surface water ecosystem impacts.

11.9.4 Criteria for assessment

ANZECC 2000 livestock drinking water guidelines and ANZECC 2018 water quality guidelines for protection of aquatic freshwater ecosystems.

ANCOLD recommends stormwater storage capacity and freeboard allowances. Note freeboard capacity is also regulated by DMIRS under the *Mines Safety and Inspection Act 1994*.

11.9.5 Applicant controls

The Applicant proposed the TSF stormwater storage capacity and freeboard allowances listed in Table 34 accordance with ANCOLD requirements.

Table 34: Applicant determined stormwater and freeboard criteria

Design criteria	Beneficiation TSF	Hydromet TSF
Stormwater storage capacity	1:5 wet season plus 1:100 AEP, 72 hr flood	1:5 wet season plus 1:100 AEP, 72 hr flood
Additional freeboard	nil	1:10 AEP wind runup plus 0.3 m
Spillway	1:100,000 AEP, critical flood plus 1:10 AEP wave run-up or PMF	1:100,000 AEP, critical flood plus 1:10 AEP wave run-up or PMF

Other Applicant controls related to TSF overflow include:

- Level gauge boards and / or automated level sensors for monitoring water levels;
- Daily (two times per production shift) inspections of the tailings' facilities and monthly review of water balance;
- TSF Operations Maintenance and Surveillance Manual that provides inspection procedures and protocols to be prepared as part of the TSF detailed design phase. The manual is prepared to meet the *Guidelines on the Development of an Operating Manual for Tailings*

Storage (DME 1998); and

- Mandatory annual geotechnical audit for all TSFs prepared in accordance with DMIRS *Tailings Storage Facility Audit Guide* (DMIRS 2017).

11.9.6 Consequence

If an overflow of tailings or supernatant impacting on adjacent vegetation, groundwater or surface water from the TSFs occurs, then the impact is considered high level impact to an onsite receptor and mid level offsite impacts on a local scale. Therefore the consequence is **major**.

11.9.7 Likelihood of Risk Event

The TSFs are designed with stormwater storage, freeboard and spillways in accordance with ANCOLD standards and the Applicant will operate, maintain and monitor the TSFs in accordance with an operating manual prepared in accordance with DMIRS guidelines. Also noting that the Hydromet TSF spillway spills into the Beneficiation TSF, the likelihood of tailings or supernatant released to vegetation, soil or surface water from a TSF overflow may only occur in exceptional circumstances. Therefore, the Delegated Officer determined the likelihood of TSF overflows impacting on vegetation, surface water or groundwater to be **rare**.

11.9.8 Overall rating of TSF overflow

The Delegated Officer has compared the consequence and likelihood ratings described above with the risk rating matrix (Table 26) and determined that the overall rating for the risk of TSF overflows impacting on vegetation, soil or surface water is **Medium**.

11.10 Risk Assessment – Dewater discharge

11.10.1 Description of risk event

Frasers Pit and/or Bald Hill Pit dewater is discharged from the respective turkey's nest dams to a natural drainage line causing impacts to the surface water ecosystems and flow regimes.

11.10.2 Identification and general characterisation of emission

As discussed in Section 4.5.3, abstracted groundwater from dewatering Bald Hill Pit and Frasers Pit is directed to respective turkey's nests. During normal operating conditions, Applicant modelling shows all dewater will be utilised through dust suppression or as process water in the ore processing plant and no dewater discharge is expected.

The risk event relates to the worst-case scenario where excess dewater from the respective turkey's nests will be discharged to the nearest drainage line. The modelled worst-case scenario relates to a scheduled or unscheduled plant shutdown coinciding with a 1:100 year ARI rainfall event. During shutdown of the plant, up to 14 days in a worst-case scenario, the pits will continue to be dewatered and may exceed the capacity of the water storage structures.

The Applicant's water balance model shows the maximum dewater rate will occur during January to March 2025 when a dewatering discharge of 2,454 tpd is expected. During normal operations, it is proposed for 1,246 tpd will be used for dust suppression; therefore during shutdowns more than half of dewater discharge will be utilised for dust suppression. If the shutdown continues for 14 days and coincides with an extreme rainfall event, a maximum of 34,356 tonnes per 14 day event will be discharged to drainage lines.

The Applicant provided water quality sampling data from production bores at Frasers pit and Bald Hill pit as shown in Table 35. The key parameters are the slightly alkaline pH (8 to 8.5), fresh to slightly brackish salinity (1000 to 1200 mg/L TDS) and of sodium chloride type.

Table 35: Frasers Pit and Bald Hill Pit production bore water quality results (Source: Application)

Analyte	Unit	FRW03	BHW05
pH	pH unit	8.5	8.0
Electrical Conductivity	µS/cm	2,100	1,900
Total Dissolved Solids (TDS)	mg/L	1,200	1,000
Carbonate Alkalinity	mg/L	11	<1
Bicarbonate Alkalinity	mg/L	280	<5
Chloride	mg/L	380	330
Sulphate	mg/L	160	100
Nitrite	mg/L	<0.2	<0.05
Nitrate	mg/L	9.1	65
Calcium	mg/L	72	81
Magnesium	mg/L	67	51
Potassium	mg/L	9.5	9.0
Silica	mg/L	52	72
Silicon	mg/L	-	34
Sodium	mg/L	230	240
Total Hardness	mg/L	460	410
Aluminium	mg/L	<5	<5
Iron	mg/L	73	9
Manganese	mg/L	<1	<1

The Applicant surmises that based on the water quality data, a dewater discharge would not have a significant or deleterious impact on the chemical and biological water quality of the groundwater, and the water will be diluted via the respective rainfall event.

11.10.3 Description of potential adverse impact from the emission

Physical impacts to the environment through erosion of sub-surface sediments during the discharge due to the high velocity of discharge and smothering of vegetation by sediment and silt.

11.10.4 Criteria for assessment

ANZECC 2000 livestock drinking water guidelines.

11.10.5 Applicant controls

The Application states the following control measures for dewater discharges:

- Overflow pipe to convey water to the nearest drainage line;
- A spreader pipe from the discharge point to manage flow into the creek to reduce inundation downstream of the discharge point;
- Rock pitching at the discharge point to disperse kinetic energy and protect bed and banks adjacent to the discharge point; and
- Water quality monitoring

11.10.6 Consequence

Having regard to the design controls and the modelling, the Delegated Officer has determined the consequence of dewater discharge to be **slight**.

11.10.7 Likelihood of Risk Event

The Delegated Officer has determined the likelihood of dewater discharge impacting on the surface water ecosystems or flow regimes to be **rare**.

11.10.8 Overall rating of dewater discharges

The Delegated Officer has compared the consequence and likelihood ratings described above with the risk rating matrix (Table 26) and determined that the overall rating for the risk of dewater discharges is **Low**.

11.11 Risk Assessment – Landfilling

11.11.1 Description of risk event

Contaminated stormwater runoff or leachate seepage from the Bald Hill or Frasers waste rock dump landfills impacts on the beneficial use of groundwater or a surface water ecosystem.

11.11.2 Identification and general characterisation of emission

Putrescible and inert waste will be buried in bunkers to be located to the north and south of the ore processing plant within the Frasers (south) and Bald Hill (north) waste rock landforms. The Application states 670 tpa of putrescible waste, and 2,500 tpa of inert waste (3,170 tpa in total) will be disposed of to landfill. Inert waste buried will be the portions that cannot recovered during sorting near the ore processing plant for recycling or reuse. Two bunkers will be active at any one time.

Bowman 2018 states that the specific waste streams to putrescible landfill bunkers will be: general (putrescible) waste, foodwaste, glass bottles, dirty paper/cardboard, oily rags, oily filters and used gloves.

Bowman 2018 states that the inert landfill bunkers will receive timber, pallets, dirty plastic buckets and containers, light vehicle tyres, haulpak tyres, hoses, plastic piping, conveyor belt and packaging. The Delegated Officer notes that wastes such as timber and pallets are not considered inert.

Once a bunker becomes full, a new bunker will be formed from waste rock and the locations of the bunkers will move throughout the waste rock landform to suit the current tipping locations of the haulpak trucks.

11.11.3 Description of potential adverse impact from the emission

Should contaminated leachate reach groundwater, there is the potential that it will be transported to groundwater dependent ecosystems.

In consideration of likely dilution factors applied to leachate should it reach groundwater, the Delegated Officer considers that concentrations of contaminants within groundwater will be unlikely to result in impacts to groundwater dependent ecosystems.

11.11.4 Criteria for assessment

The Landfill Definitions are used to classify waste types and identify appropriate landfill types for their disposal. DER 2014 provides criteria for assessing groundwater contamination.

11.11.5 Applicant controls

The controls for stormwater and leachate described in Table 36 are taken from the Application.

Table 36: Applicant landfill controls for stormwater and leachate

Control	Description
Infrastructure / design controls	• Small size, nominally 50 m long x 10 m wide and 2 m deep • Bunkers slightly sloped (approx. 2%) to the rear to retain stormwater collected in bunkers • Stormwater diversion drainage • Embankments
Management / Procedures	• Daily inspections of tipping faces • Waste compacted as soon as practicable to reduce potential for windblown litter • Daily cover on putrescible waste bunker • Leachate contained in the bunker until evaporated • Transfer excessive leachate to the drainage sediment pond behind the waste depot where it can be evaporated • Direct away uncontaminated stormwater • Drains kept clear • Any water in contact with waste contained within the bunker • Pre-sorting of waste near the ore processing facility • Exclusion of wastes such as hazardous, dangerous goods, radioactive, medical wastes and also contaminated soils and sludges.

11.11.6 Consequence

Considering the size and scale of the landfill bunkers, location within waste rock dumps and the dilution factors likely to be applied to leachate reaching groundwater, the Delegated Officer has determined that the consequence of landfill leachate reaching groundwater is **slight**.

11.11.7 Likelihood of Risk Event

Based upon the comparatively small quantities of waste, high evaporation rates, depth to groundwater and dilution factors for any leachate that enters groundwater, the Delegated Officer has determined that the likelihood of the risk event is **rare** if the bunkers are designed as proposed and waste of the type and quantities is buried.

11.11.8 Overall rating of landfilling

The Delegated Officer has compared the consequence and likelihood ratings described above with the risk rating matrix (Table 26) and determined that the overall rating for the risk of landfilling is **Low.**

11.12 Risk Assessment – WWTP loss of containment and treated effluent irrigation

11.12.1 Description of risk event

Loss of containment events resulting in the discharge of raw, partially treated or treated effluent to land. Treated effluent is irrigated to an adjacent sprayfield. Discharges to land through loss of containment or irrigation may contaminate soil or impact on the beneficial use of groundwater.

11.12.2 Identification and general characterisation of emission

The Applicant will be installing and operating a five stage Bardenpho activated sludge wastewater treatment plant (the WWTP) near the ore processing facility. The WWTP has a maximum design capacity of 34 m^3/day. The Application states the system is designed to treat effluent to "W.A. Class C standards". The Delegated Officer referred to the *National Water Quality Management Strategy, Australian Guidelines for Sewage Systems, Effluent Management*, ANZECC and ARMCANZ 1997 (NWQMS 1997) which provides the following typical effluent qualities following a Class C level of treatment with secondary treatment:

- Biochemical oxygen demand – 20 to 30 mg/L.
- Total suspended solids 25 to 40 mg/L.
- Total nitrogen – 20 to 50 mg/L.
- Total phosphorus 6-12 mg/L.
- *E.coli* – 10^5 to 10^6 org/100 ml.
- Anionic surfactants <5 mg/L.
- Oil and grease < 10 mg/L.

The Applicant has similarly proposed a five stage Bardenpho treatment system for accommodation village WWTP to be constructed under works approval W6158/2018/1. Treated effluent from the accommodation village WWTP will also meet NWQMS 1997 Class C standards with the following effluent specification provided as listed below. The Delegated Officer has assumed the effluent specifications will be the same for the ore processing facility WWTP.

- pH – 6.8-8.5.
- Biochemical oxygen demand - <20 mg/L.
- Total suspended solids - <30 mg/L.
- Total nitrogen - <30 mg/L.
- Total phosphorus - <8 mg/L.
- E.coli - <1000 cfu/100 ml.

Treated effluent will be irrigated to an adjacent 10,000 m^2 (1 ha) sprayfield located to the south west of the processing plant as shown in the Ore Process Plant General Layout map in Appendix 2.

11.12.3 Description of potential adverse impact from the emission

Irrigation of treated sewage has the potential to contaminate soil impacting on its structure, impact on vegetation and impact on the beneficial use of groundwater. Given the location of the sprayfield, there is unlikely to be any risk of direct discharge to local drainage lines or creeks. It is unnecessary to further assess risks to surface water ecosystems taking into account the high evaporation rates at the site and dilution factor of any rainfall event sufficient enough to transport contaminated stormwater from the sprayfield to a surface water body.

11.12.4 Criteria for assessment

NWQMS 1997 provides typical effluent quality standards for sewage systems based on the level of treatment. Typical effluent qualities for Class C with secondary treatment are listed above in Section 11.12.2. Secondary treatment is defined by NWQMS 1997 to involve "a level of treatment that removes 85% of BOD and suspended solids."

NWQMS 1997 recommends a minimum Class C for landscape irrigation with a commonly required level also including Class E which involves additional disinfection.

11.12.5 Applicant controls

The Application details the design and treatment process for the five stage Bardenpho activated sludge which is an established package facility designed to meet a required standard of effluent treatment and treated water quality. The following controls were identified in the Application:

- Process control and system automation with alarm and fault detection systems;
- NWQMS 1997 treatment to Class C effluent quality discharging to a fenced and signed sprayfield;
- Submersible pump and high level alarm float switches on the balance tank and irrigation tan;
- Failure of mechanical components will be raised by alarms and flashing beacons, which will also be triggered when water levels exceed certain limits in the balance or irrigation tanks;
- Daily and weekly inspections of the WWTP infrastructure, tank levels and sprinkler field equipment;
- Managed in accordance with *AS/NZS 1547:2012 On-site Domestic Wastewater Management*;
- Bunding around the WWTP for protection from floodwaters and leak/spill containment; and
- Irrigation flow meter to be installed and measure effluent application rates.

11.12.6 Consequence

The WWTP is comparatively small-scale and located in proximity to the ore processing plant. Loss of containment events will result in low level localised impacts. Therefore, the Delegated Officer considers the consequence of loss of containment to be **minor**.

Sewage will be irrigated to a NWQMS 1997 Class C standard and irrigated to a managed sprayfield. Irrigation of treated effluent will result in minimal localised impact. Therefore, the Delegated Officer considers the consequence of treated effluent irrigation to be **slight**.

11.12.7 Likelihood of Risk Event

Loss of containment events are expected to result in the discharge of relatively small volumes of raw or partially treated sewage discharged to an area localised within the WWTP footprint. The Delegated Officer has determined that loss of containment events will probably not impact on groundwater in most circumstances. Therefore, the Delegated Officer considers the likelihood of loss of containment impacts to be **unlikely**.

Impacts to adjacent vegetation due to excess nutrients from the proposed irrigation of Class C treated effluent from the WWTP may only occur in exceptional circumstances. Therefore, the Delegated Officer considers the likelihood of Class C treated effluent irrigation to be **unlikely.**

11.12.8 Overall rating of treated sewage irrigation

The Delegated Officer has compared the consequence and likelihood ratings described above with the risk rating matrix (Table 26) and determined that the overall rating for the risk of WWTP loss of containment impacts to be **Medium** and impact from irrigation to be **Low**.

11.13 Summary of acceptability and treatment of Risk Events

A summary of the risk assessment and the acceptability or unacceptability of the risk events set out above, with the appropriate treatment and control, are set out in Table 37 below. Controls are described further in section 11.

Table 37: Risk assessment summary

	Description of Risk Event			Applicant controls	Risk rating	Acceptability with controls (conditions on instrument)
	Emission	**Source**	**Pathway/ Receptor (Impact)**			
1	Fugitive dust containing radionuclides	Hydromet TSF and ore processing facility	Air / wind dispersion impacting on flora and fauna	Design and management / procedure based controls summarised in section 11.4.5	Moderate consequence Unlikely likelihood **Medium risk**	Acceptable, subject to Applicant controls conditioned
2	Point source emissions to air	Ore processing facility	Air / wind dispersion impacting on ambient air quality or vegetation	Design and management / procedure summarised in section 11.5.5	Minor consequence Unlikely likelihood. **Medium risk**	Applicant subject to Applicant controls and regulatory controls conditioned.
3	Loss of containment and contaminated stormwater discharges	Ore processing facility and pipelines	Direct discharge infiltrating to groundwater impacting beneficial use.	Design and management / procedure based controls summarised in section 11.6.5.	Minor consequence Unlikely likelihood **Medium risk**	Acceptable, subject to Applicant controls conditioned
			Pipeline direct discharge to surface water		Major consequence Unlikely likelihood **Medium risk**	
4	Bird ingestion or contact with TSF supernatant	Beneficiation TSF	Ingestion or direct contact with supernatant causing tissue damage or death	Beneficiation tailings presents a potential acute impact to birds through high pH	Both: Moderate consequence Possible likelihood Preliminary rating: **Medium risk**	Subject to further investigation and potentially regulatory control
		Hydromet TSF		Hydromet tailings may present a chronic impact from radionuclides exposure		
5	TSF seepage	Beneficiation TSF	Migration into groundwater impacting on either hyporheic ecosystems in adjacent drainage line,	Design and management / procedure based controls summarised in section 11.8.5	On livestock water quality: Minor consequence Rare likelihood **Low risk**	Acceptable, subject to Applicant controls and regulatory controls conditioned

	Description of Risk Event			Applicant controls	Risk rating	Acceptability with controls (conditions on instrument)
	Emission	**Source**	**Pathway/ Receptor (Impact)**			
			or livestock drinking water		On hyporheic ecosystems: Moderate consequence Unlikely likelihood **Medium risk**	
		Hydromet TSF			Both for livestock or hyporheic ecosystem: Moderate consequence Unlikely likelihood **Medium risk**	
6	TSF overflow of tailings slurry and/or supernatant	Beneficiation TSF and/or Hydromet TSF	Direct discharge damaging surrounding vegetation, impacting on surface water ecosystems or the beneficial use of groundwater	Design and management / procedure based controls summarised in section 11.9.5	Major consequence Rare likelihood **Medium risk**	Acceptable, subject to Applicant controls and regulatory controls conditioned
7	Dewater discharge during modelling worst-case events	Frasers and/or Bald Hill turkeys nests	Direct discharge to nearby natural drainage line	Overflow pipe, spreader pipe, rock pitches and monitoring	Slight consequence Rare likelihood **Low Risk**	Acceptable, subject to Applicant design controls conditioned
8	Landfill leachate seepage	Fraser and Bald Hill waste rock dumps	Direct discharge infiltrating to groundwater	Design and management / procedure based controls summarised in section 11.11.5	Slight consequence Rare likelihood **Low Risk**	Acceptable, subject to Applicant controls conditioned for design and waste types
9	Raw or partially treated sewage loss of containment	Ore processing facility WWTP	Direct discharge infiltrating to groundwater	Design and management / procedure based controls summarised in section 11.12.5	Minor consequence Unlikely likelihood **Medium Risk**	Acceptable, subject to Applicant controls for design specification and regulatory control for inspections; additional contingency

	Description of Risk Event			Applicant controls	Risk rating	Acceptability with controls (conditions on instrument)
	Emission	**Source**	**Pathway/ Receptor** **(Impact)**			
						storage to be made available for storage of treated wastewater during wet weather events
10	Treated sewage irrigation	Ore processing facility WWTP	Direct discharge to sprayfield impacting on adjacent vegetation (excess nutrient runoff)	Design and management / procedure based controls summarised in section 11.12.5	Slight consequence Unlikely likelihood **Low risk**	Acceptable, subject to Applicant controls for treated effluent quality specification

12. Regulatory controls

The risks are set out in the assessment in Section 11 and the controls are detailed in this section. The Delegated Officer will determine controls having regard to the adequacy of controls proposed by the Applicant. The conditions of the works approval will be set to give effect to the determined regulatory controls.

12.1 Works approval controls – fugitive dust

12.1.1 Infrastructure and equipment (design and construction)

The installation of sprinkler systems and covers for the ROM pad (as detailed in section 11.4.5) will be conditioned.

12.1.2 Infrastructure and equipment (time limited operations)

The Applicant will be required to maintain a wet surface on the Hydromet TSF. The method of achieving this is for the Applicant to determine. The Delegated Officer is satisfied there are sufficient controls available to achieve this.

For any extended period of shutdown or if the Premises enters a period of care and maintenance, (where operations are ceased), the Applicant will be required to regularly apply a dust suppressant to the surface of the Hydromet TSF.

As noted in section 11.4.5, an ambient air quality monitoring program assessing radionuclides concentrations in dust will be completed as part of the Premises' commitments under their Radiation Management and Radioactive Waste Management Plans. These aspects will not be conditioned as part of this Works Approval beyond a requirement to include the data obtained from this monitoring program in the Compliance Report for Time Limited Operations and the eventual Annual Environmental Report required by the subsequent Licence.

12.2 Works Approval controls – point source emissions to air

12.2.1 Infrastructure and equipment (design and construction)

The following requirements will be included in the works approval:

- ABK stacks that have monitoring ports that meet AS 4323.1.
- ABK pollution control equipment that meets specified design and construction requirements (refer to section 11.5.5).
- Install CEMS for monitoring SO_2, CO, HF and SO_3 emissions from the ABK Normal Stack that meets EN14181.

Grounds: Monitoring ports on the ABK stacks allow for stack monitoring to occur during the initial periods of operating under works approval for validation of air emissions and also validation against CEMS. Monitoring locations and ports that meet AS4323.1 improves data accuracy and reliability. Engineering design measures incorporated into the ABK design are intrinsic to emission control and emission outcomes.

12.2.2 Infrastructure and equipment (time limited operations)

The following requirements will be included in the works approval:

- Air emissions points (ABK stacks and power station stacks) will be specified as authorised emission points.
- The Applicant will be required to ensure pollution abatement equipment on the ABK is active and operational when the source is operational. This includes ensuring that the emergency

scrubbing system is ready and available for use prior to restarting the ABK after an emergency shutdown event.

- Operate and maintain CEMS on the ABK Normal Stack

Grounds: As above. Emission control technology specified in the infrastructure design and construction requirements will be specified under operational requirements.

12.2.3 Emission limits (operation)

Point source emission limits will be specified as per Table 38.

Table 38: Proposed emission limits

Parameter	Stack reference	Recommended limit	Justification for the limit value proposed
H_2SO_4 / SO_3 (as SO_3 equivalent)	ABK Normal Stack	45 mg/m^3	Reference emission limits within Schedule 4 of the *NSW Protection of the Environment Operations (Clean Air) Regulations 2010* were taken into consideration. Derived limits in the works approval are based on the applicant's air emission design criteria and consideration of its air quality impact assessment.
HF		50 mg/m^3	

12.2.4 Monitoring (operation)

Monitoring of discharges to air from the ABK normal stack will be included in the works approval:

- At least two separate ABK Normal Stack sampling events upon the commencement of operating the ABK.
- ABK Normal Stack CEMS

Grounds: CEMS data during the initial stages of operating under the works approval will demonstrate the acceptability of the constructed works and accuracy of the estimated emissions in the Applicant's air emissions assessment. As the CEMS are design to comply with EN14181, the Applicant will be require to undertake initial stack sampling events to demonstrate the accuracy and reliability of the CEMS. It is expected that based on the CEMS installed, requirements for stack sampling will not form an ongoing operational requirement.

Monitoring of the ABK Emergency stack is not proposed. Emissions are expected to occur infrequently for short periods of time during emergency events. The emissions profile is expected to be similar to normal operating conditions except for short-term elevated acid gas concentrations. CEMS on the ABK Emergency Stack is therefore viewed as excessive in the circumstances and period stack monitoring by its nature would not provide meaningful data of emissions to air during an emergency event.

12.2.5 Monitoring reports (operations)

The following requirements will be included in the works approval:

- Requirement to submit a report on air emissions monitoring specified in the works approval including:
  - Sample analysis reports;
  - Analysis of sampling methods against standards;
  - Comparison of results against any limits specified in the works approval; and
  - Commentary on how the emissions compare with works approval application modelling inputs and design criteria.

12.2.6 Notifications

The Applicant will be required to notify DWER of any exceedances of limits specified in the works approval.

12.3 Works approval controls – loss of containment (ore processing facility and pipelines)

12.3.1 Infrastructure and equipment (design and construction)

Secondary bunding for all tailings pipeline corridors will be required to be installed as per the controls listed in section 11.6.5. The processing plant shall have concrete bunding installed in accord with the details in section 11.6.5. The stormwater runoff pond shall be constructed in accord with that section.

12.3.2 Infrastructure and equipment (commissioning and time limited operations)

Inspection of infrastructure bunding capacity shall be completed after each storm event to ensure availability of bunding to contain further events.

12.4 Works approval controls – TSFs (seepage and potential impact to birds)

12.4.1 Infrastructure and equipment (design and construction)

Applicant controls as detailed in section 11.8.5 will be conditioned in the Works Approval. QA/QC procedures for installation of the geomembrane composite liner for the Hydromet TSF and the compacted clay liner for the Beneficiation TSF will be required to be followed to ensure the installation of the respective liners is completed in according with industry best practice and that post installation identification and repair of any holes in the geomembrane liner is completed prior to commissioning.

Baseline monitoring of groundwater bores, including Fraser's Well and the surface water monitoring will be completed prior to tailings deposition occurring. The monitoring suite will include REEs in addition to the parameters proposed in Table 33.

12.4.2 Infrastructure and equipment (time limited operations)

Groundwater and surface monitoring programs will be in operation during this time. Inspections as detailed in section 11.8.5 will be conditioned, including a requirement to conduct monthly water balances over both TSFs.

Specified actions will also be conditioned:

- An investigation of fluoride, molybdenum and REEs concentrations in Beneficiation tailings decant recycle to assess whether these contaminants are increasing in concentration over time in the processing circuit.
- A sampling program of Hydromet TSF pore water to confirm contaminant concentrations are as expected by the Application, and consistent with the original TSF3 data.
- Complete and submit a whole site GoldSim water balance using data obtained during Time Limited Operations to confirm assumptions of the preliminary water balance (as detailed in the Application).
- A desktop assessment of potential fauna impacts from exposure to both TSFs will be required to commence during time limited operations.

These specified actions will be transferred to the Licence where appropriate.

12.5 Works approval controls – TSFs (overflow)

12.5.1 Infrastructure and equipment (design and construction)

The submitted TSF design with the provision for storm and wave runoff freeboard and spillways will be conditioned. Installation of level gauges and/ or automated level control on the TSFs will also be conditioned.

12.5.2 Infrastructure and equipment (commissioning and time limited operations)

Regular inspections of the freeboard availability as detailed in section 11.9.5 will be conditioned.

12.6 Works approval controls – Dewater discharge

No specific controls are required in the works approval apart from authorising the discharge points. It is noted that this event is low risk, and highly unlikely to occur, however the Applicant controls for managing the velocity of the discharge will be conditioned for operation (Time Limited Operations or Licence).

12.7 Works approval controls – Landfills

12.7.1 Infrastructure and equipment (design and construction)

The works approval will condition the location of the landfills (within the waste dump footprints) and the dimensions of the landfill trenches. Additional trenches may be constructed as required provided the trenches conform to these requirements.

12.7.2 Infrastructure and equipment (time limited operations)

Applicant controls as detailed in Table 36: Applicant landfill controls for stormwater and leachateTable 36 will be conditioned. This includes the frequency and subject of inspections. The daily placement of backfill material will also be conditioned.

12.8 Works approval controls – Sewage treatment and irrigation

12.8.1 Infrastructure and equipment (design and construction)

The five stage Bardenpho treatment system as detailed in section 4.5.7 and the location and area of the irrigation sprayfield will be conditioned in the Works Approval. Perimeter bunding as per section 11.12.5 will also be required to be installed to divert stormwater away from the WWTP.

The Applicant will be required to provide contingency wet weather storage. This will be 5,000L storage capacity within each pump station and a further capacity of 15 KL within the balance and irrigation tanks and is equivalent to approx. 1 day of contingency storage.

12.8.2 Infrastructure and equipment (time limited operations)

Inspections and maintenance of the WWTP and irrigation sprayfield infrastructure will be conditioned for during the Time Limited Operations period of the Works Approval.

12.8.3 Monitoring (commissioning and time limited operation)

By the end of the three month commissioning period the Applicant will be required to sample the treated effluent quality and demonstrate that it meets the Class C standard (NQWMS 1997).

Monthly sampling of treated effluent will be required during any remaining time limited operation period. Monthly monitoring will be required to continue during the Licence period.

13. Licence controls

The Works Approval allows the Applicant to undertake works, subject to condition, in addition to allowing a finite period of emissions from the Rare Earths Facility during time limited operations, also subject to conditions.

It is expected the Applicant will apply for a Licence towards the completion of works as it progresses into time limited operations under the Works Approval. The determined controls for a Licence will generally be consistent with the Works Approval operation based conditions outlined in section 12.

14. Applicant's comments

The Applicant was provided with the draft Decision Report and draft issued Works Approval on 4 June 2020. The Applicant responded on 8 June 2020 providing clarification on contingency wet weather storage for WWTP treated effluent and also provided updated site maps required by DWER.

15. Conclusion

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

Alana Kidd
Manager Resource Industries
Delegated Officer
under section 20 of the *Environmental Protection Act 1986*

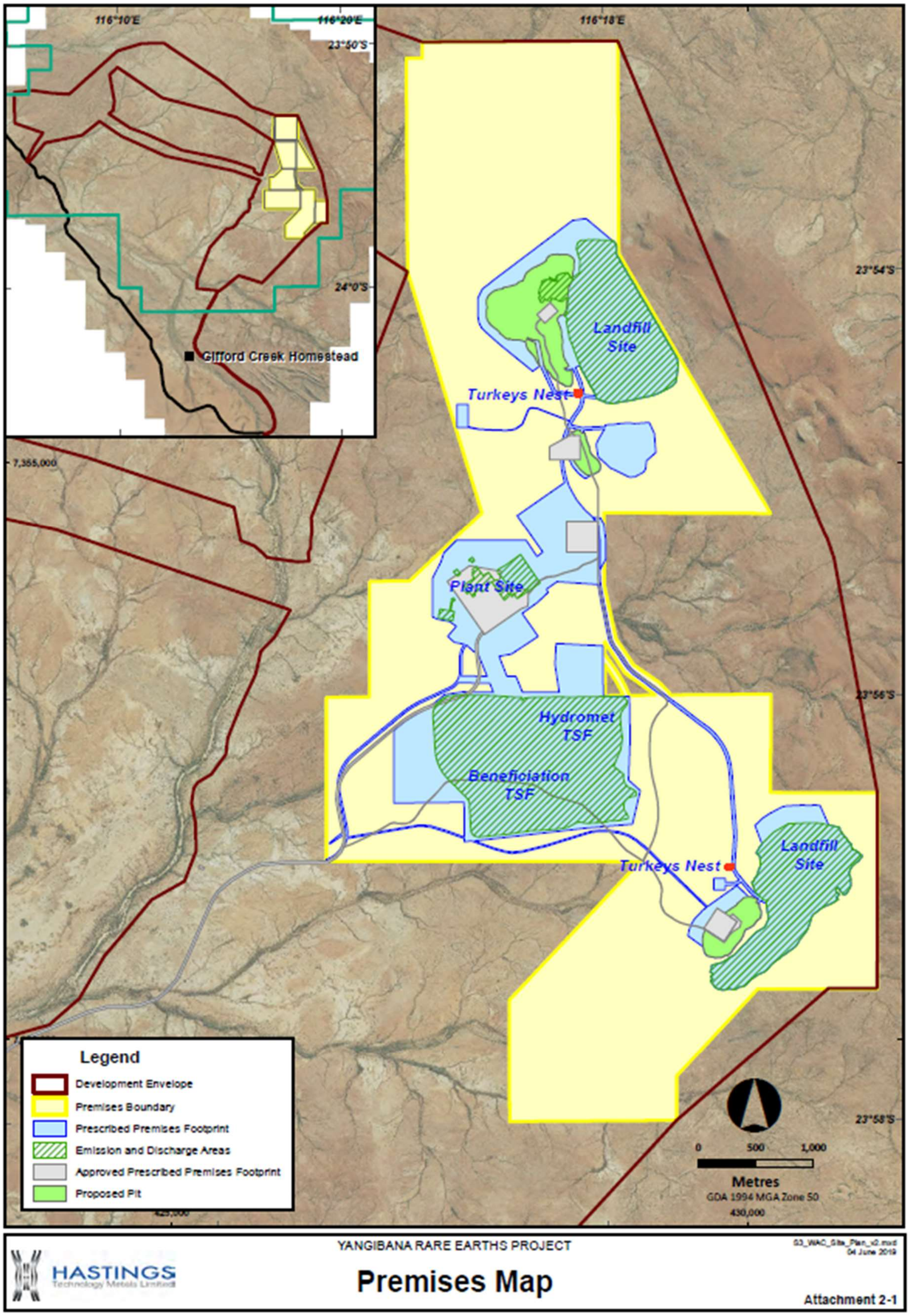
Appendix 1: Key documents

	Document title	In text ref	Availability
1.	Agriculture and Resource Management Council of Australian and New Zealand (ARMCANZ) & Australian and New Zealand Environment and Conservation Council (ANZECC) (1997) *National Water Quality Management Strategy: Australian Guidelines for Sewerage Systems Effluent Management*	NWQMS 1997	https://www.waterquality.gov.au/sites/default/files/documents/effluent-management.pdf
2.	ANZECC & ARMCANZ (2000/2018) *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*	ANZECC 2018	https://www.waterquality.gov.au/anz-guidelines
3.	ATC Williams (2018) *Feasibility Study Design Tailings Storage Facilities, Yangibana Project, Western Australia*. Report 112391.12 R01 Rev 0, August 2018.	ATCW 2018	DWER records (A1799918) – Appendix B in Attachment 8 of the Application
4.	Bowman and Associates (2018) *Hastings Technology Metals Yangibana Rare Earth Project Waste Management Supporting Document,* November 2018	Bowman 2018	DWER records (A1799918) Appendix Q in Attachment 8 of the Application
5.	Cooper, A.F., Paterson, L.A. and Reid, D.L., 1995. Lithium in carbonatites - consequence of an enriched mantle source? *Mineralogical Magazine*, **59**, 401-408.	Cooper *et al.*, 1995	http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.612.5785&rep=rep1&type=pdf.
6.	DER (2014) *Assessment and Management of Contaminated Sites,* Department of Environment Regulation, Perth, December 2014.	DER 2014	https://www.der.wa.gov.au/images/documents/your-environment/contaminated-sites/guidelines/Assessment_and_management_of_contaminated_sites.pdf
7.	DER, July 2015. *Guidance Statement: Regulatory principles.* Department of Environment Regulation, Perth.	N/A	www.dwer.wa.gov.au
8.	DER, October 2015. *Guidance Statement: Setting conditions.* Department of Environment Regulation, Perth.		
9.	DER, August 2016. *Guidance Statement: Licence duration.* Department of Environment Regulation, Perth.		
10.	DER, February 2017. *Guidance Statement: Risk Assessments*. Department of Environment Regulation, Perth.		
11.	DER, February 2017. *Guidance Statement: Decision Making*. Department of Environment Regulation, Perth.		
12.	DWER (2019) *Landfill Waste Classification and Waste Definitions 1996 (as amended 2019)*, Department of Water and Environmental Regulation, Perth.	DWER 2019	https://www.der.wa.gov.au/images/documents/our-work/licences-and-works-approvals/WasteDefinitions-revised.pdf

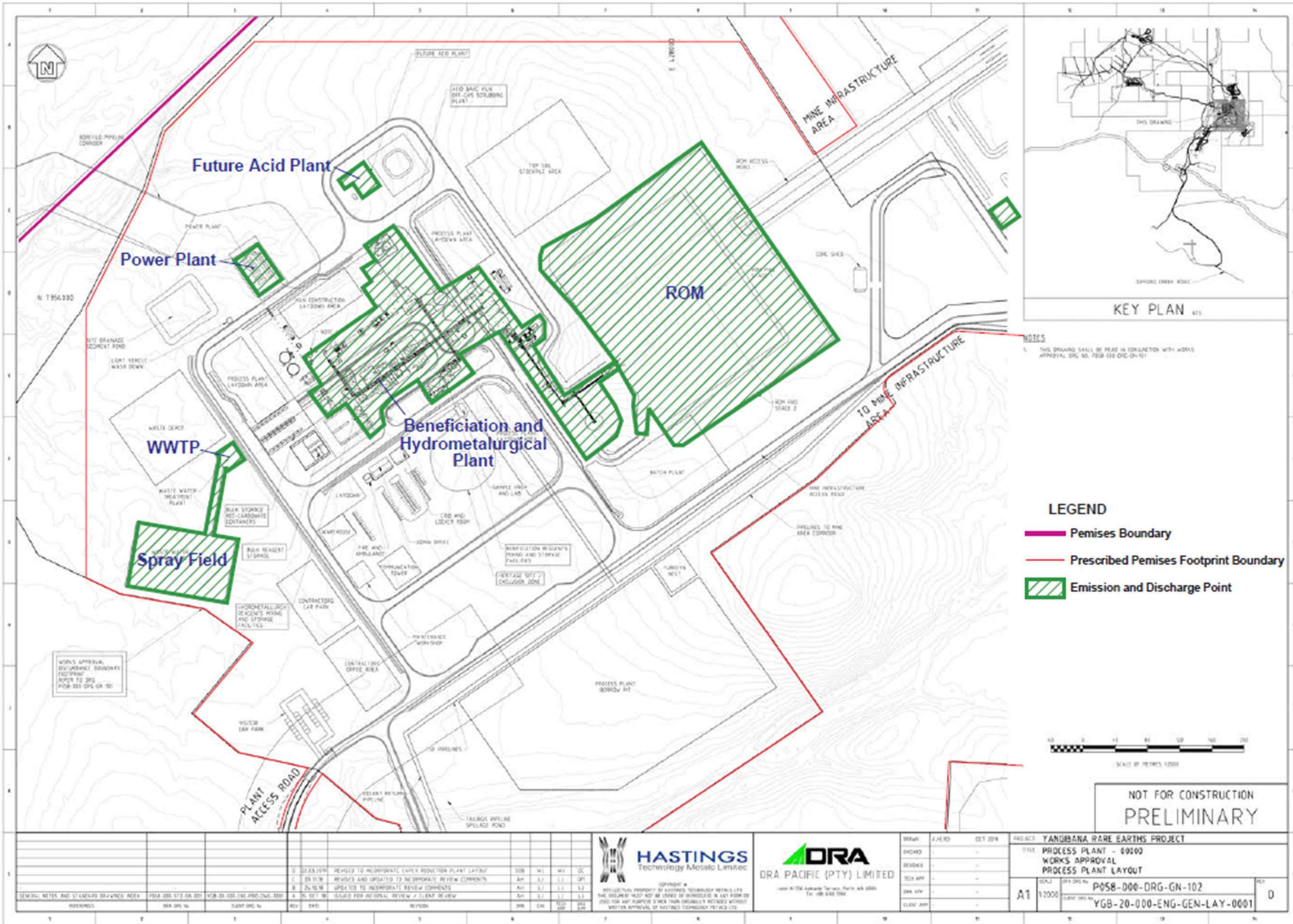
	Document title	In text ref	Availability
13.	EPA (2019) *EPA Report 1642 Yangibana Rare Earths Project Hastings Technology Metals Pty Ltd,* Environment Protection Authority, Perth.	EPA 2019	http://www.epa.wa.gov.au/sites/default/files/EPA_Report/Yangibana%20Rare%20Earths%20Project%20-%20EPA%20Report.pdf
14.	ERM (2018) *Yangibana Rare Earths Project: Plume Study,* October 2018.	ERM 2018	DWER records (A1799918) – Appendix A of Attachment 8 to the Application
15.	ERM (2019) *Hastings Yangibana Rare Earths Project: Revision to the Plume Study*, October 2019.	ERM 2019	DWER records (A1861965) – Appendix A to Supplementary Information sent to DWER from Hastings Technology Metals Pty Ltd, dated 5 December 2019.
16.	Department of Agriculture, Water and Environment (2016) *EPBC Act Referral EPBC2016/7845,* Commonwealth of Australia, Canberra.	EPBC2016/7845	http://epbcnotices.environment.gov.au/_entity/annotation/2a89ddc8-3475-ea11-962c-00505684324c/a71d58ad-4cba-48b6-8dab-f3091fc31cd5?t=1588314992437
17.	GHD (2019) *Yangibana TSF Design Development Preliminary Design Report*. Report YGB-31-100-ENG-CIV-REP-0001, Revision 1, June 2019.	GHD 2019	DWER records (A1799918) – Appendix C of Attachment 8 of the Application
18.	Maest, A.S. and Kuipers, J.R., 2005. *Predicting Water Quality at Hardrock Mines: Methods and Models, Uncertainties and State-of-the-Art*. Technical report which is available from web site	Maest and Kuipers, 2005	https://www.waterboards.ca.gov/academy/courses/acid/supporting_material/predictwaterqualityhardrockmines1.pdf.
19.	Ministerial Statement MS 1110, dated 9 August 2019, State Government of Western Australia, Perth.	MS 1110	http://www.epa.wa.gov.au/sites/default/files/1MINSTAT/1642%20Statement%201110%20for%20publishing.pdf
20.	National Health and Medical Research Council NHMRC, 2011 updated May 2019. *Australian Drinking Water Guidelines Paper 6 National Water Management Strategy,* National Health and Medical Research Council, Commonwealth of Australia, Canberra.	NHMRC 2011	https://www.nhmrc.gov.au/about-us/publications/australian-drinking-water-guidelines#block-views-block-file-attachments-content-block-1
21.	USEPA, 2012. *Rare Earth Elements*: *A Review of Production, Processing, Recycling and Associated Environmental Issues*. US EPA Report EPA 600/R-12/572.	USEPA 2012	www.epa.gov.
22.	USGS, 2010. *A Deposit Model for Carbonatite and Peralkaline Intrusion-Related Rare Earth Element Deposits*. U.S. Geological Survey Scientific Investigations Report 2010-5070-J.	USGS 2010	https://pubs.usgs.gov/sir/2010/5070/j/pdf/sir2010-5070J.pdf.
23.	Verplanck, P.L., Van Gosen, B.S.,Seal, R.R. and McCafferty, A.E., 2014. *A deposit model for carbonantite and peralkaline intrusion-related rare earth element deposits*. U.S. Geological Survey Scientific Investigations Report 2010-5070-J.	Verplanck *et al.* 2014	https://pubs.usgs.gov/sir/2010/5070/j/pdf/sir2010-5070J.pdf

Appendix 2: Premises maps and drawings

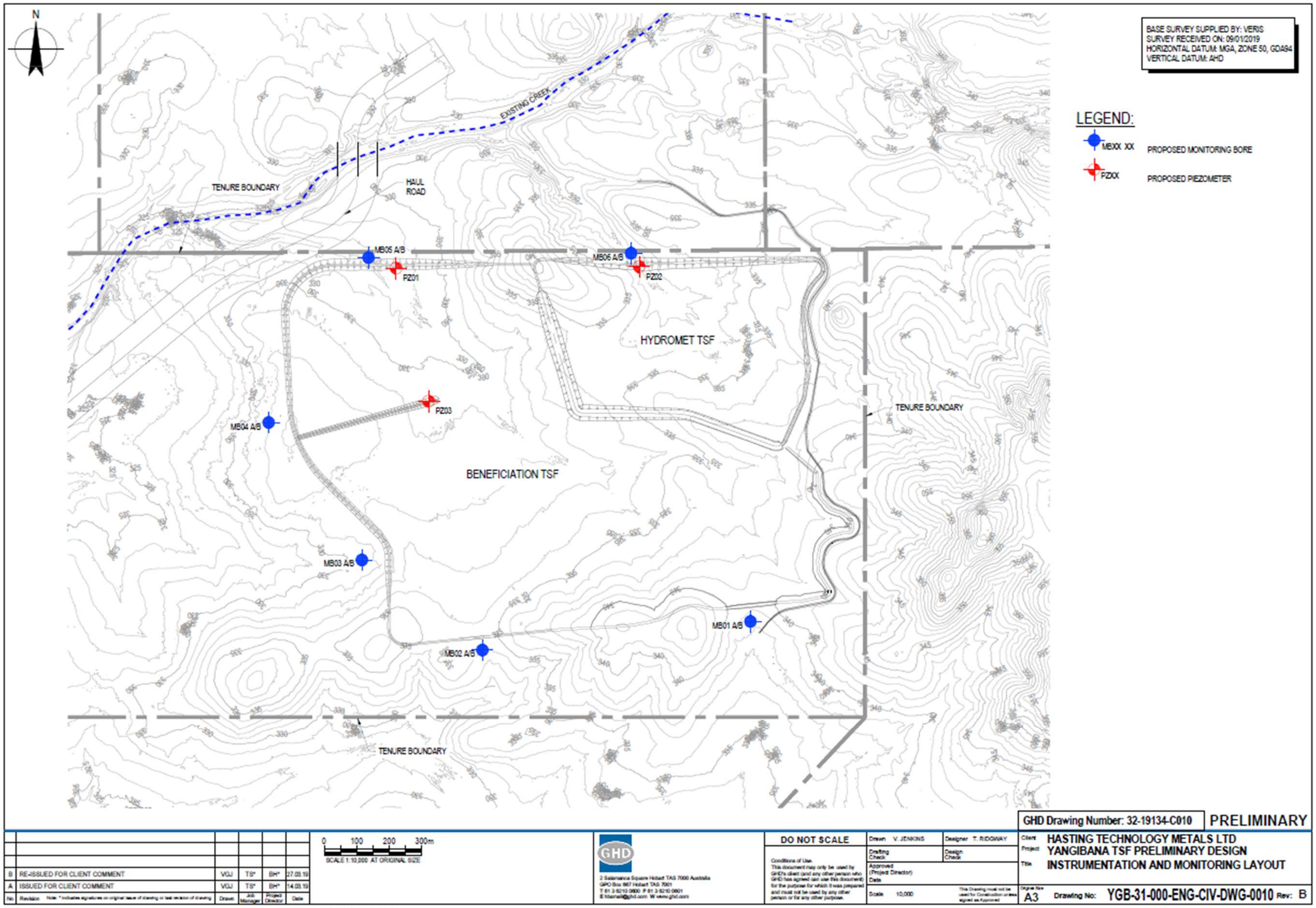
Premises general layout map



Ore process plant general layout map



Applicant TSF site layout (showing indicative TSF monitoring bore locations)



Appendix 3: Tailings Geochemical data

Table 39: LEAF and leach pore water compared to ANZECC 2000 livestock guidelines (Source: Table 5-8 in GHD 2019)

		LAB PHYS.			METALS														
Sample ID	Date	TDS	Ca	SO_4	Al	As	B	Cd	Cr	Co	Cu	Mn	Hg	Mo	Ni	Se	U	Zn	F
Units		(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)
ANZECC (2000) Livestock		**<2000-5000**	**1,000**	**1,000**	**5**	**0.5**	**5.00**	**0.01**	**1**	**1**	**0.5**	**0.1**	**0.002**	**0.05**	**1**	**0.02**	**0.2**	**20**	**2**
LOR		**1**	**1**	**1 (10)**	**0.01**	**0.001**	**0.00**	**0.0001**	**0.001**	**0.001**	**0.001**	**0.001**	**0.0001**	**0.001**	**0.001**	**0.01**	**0.001**	**0.005**	**0.1**
T01 - pH 13.0	29/03/2019	21300	**0.5**	4	15.7	0.021	0.08	**0.00005**	0.004	**0.0005**	0.004	0.005	**0.00005**	0.064	**0.0005**	**0.005**	0.064	0.075	4.8
T02 - pH 12.0	29/03/2019	696	**0.5**	5	2.37	0.007	0.06	**0.00005**	0.001	**0.0005**	0.002	0.061	**0.00005**	0.037	**0.0005**	**0.005**	0.002	0.196	0.5
T03 - pH 10.5	29/03/2019	138	**0.5**	6	4.33	0.006	0.28	0.0003	0.013	0.008	0.017	2.35	**0.00005**	0.01	0.012	**0.005**	0.006	0.291	0.6
T04 - pH 9.0	23/04/2019	168	3.0	**0.5**	0.02	**0.0005**	**0.025**	0.0001	**0.0005**	**0.0005**	0.004	0.054	**0.00005**	0.024	**0.0005**	**0.005**	0.002	0.019	0.6
T05 - pH 8.0	23/04/2019	222	11.0	**0.5**	0.02	**0.0005**	**0.025**	**0.00005**	**0.0005**	**0.0005**	0.004	0.034	**0.00005**	0.02	**0.0005**	**0.005**	0.002	0.167	0.6
T06 - pH Neutral	29/03/2019	428	34	6	0.03	**0.0005**	0.18	0.0004	**0.0005**	**0.0005**	0.004	1.03	**0.00005**	**0.0005**	0.005	**0.005**	**0.0005**	0.585	0.3
T07 - pH 5.5	23/04/2019	456	39	**0.5**	0.01	**0.0005**	0.07	0.0004	**0.0005**	0.004	0.004	2.4	**0.00005**	**0.0005**	0.012	**0.005**	**0.0005**	0.689	0.2
T08 - pH 4.0	23/04/2019	663	62	**0.5**	4.39	0.004	0.34	0.0033	0.006	0.059	0.03	13.3	**0.00005**	**0.0005**	0.045	**0.005**	0.023	1.21	1.2
T09 - pH 2.0	29/03/2019	5370	65	5	19.5	0.034	0.53	0.0042	0.08	0.141	0.198	35	**0.00005**	**0.0005**	0.08	0.04	0.265	1.58	1
B01 - Neutral	29/03/2019	**0.5**	**0.5**	**0.5**	0.01	**0.0005**	**0.025**	**0.00005**	**0.0005**	**0.0005**	**0.0005**	0.014	**0.00005**	**0.0005**	**0.0005**	**0.005**	**0.0005**	0.014	0.05
B02 - pH 2.0	29/03/2019	8640	**0.5**	5	0.02	**0.0005**	**0.025**	**0.00005**	**0.0005**	**0.0005**	**0.0005**	0.009	**0.00005**	**0.0005**	**0.0005**	**0.005**	**0.0005**	0.01	0.05
B03 - pH 13	29/03/2019	23100	**0.5**	**0.5**	0.17	**0.0005**	**0.025**	**0.00005**	**0.0005**	**0.0005**	0.005	0.003	**0.00005**	0.002	**0.0005**	**0.005**	**0.0005**	0.072	3.8
Hastings pilot plant filtrate	29/03/2019	3390	-	182	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.6

Half Detection Limit
ANZECC (2000) Livestock = between trigger and 10X
ANZECC (2000) Livestock = between 10X and 100X
ANZECC (2000) Livestock = between 100X and 1000X
ANZECC (2000) Livestock = >1000X

Bold values are half the detection limit

Table 40: LEAF leach and pore water compared to Australian drinking water values (NHRMC 2011) and ANZECC (2018) default guideline values for 95% protection of freshwater aquatic ecosystems (both referred to as NEPM below) (Source Table 5-9 in GHD 2019)

		LAB PHYS.		METALS																	
Sample ID	Date	Lab pH	SO_4	Al	Sb	As	Ba	Cd	Cr III	Cu	Pb	Mn	Hg	Mo	Ni	Se	Ag	U	B	Zn	F
Units		-	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)
NEPM Drinking Water		-	**500**	**NA**	**0.003**	**0.07**	**0.7**	**0.002**	**0.05**	**2**	**0.01**	**0.5**	**0.001**	**0.05**	**0.02**	**0.01**	**0.1**	**0.02**	**4**	**0.008**	**1.5**
NEPM Fresh water		-	**NA**	**0.055**	**NA**	**NA**	**NA**	**0.0002**	**0.001**	**0.0014**	**0.0034**	**1.9**	**0.0006**	**NA**	**0.011**	**0.011**	**0.00005**	**NA**	**0.37**	**0.015**	**NA**
LOR		-	**1**	**0.001**	**0.002**	**0.02**	**0.05**	**0.002**	**0.001**	**0.05**	**0.02**	**0.01**	**0.0001**	**0.002**	**0.05**	**0.01**	**0.001**	**0.001**	**0.05**	**0.05**	**0.1**
T01 - pH 13.0	29/03/2019	12.8	4	15.7	**0.0005**	0.021	0.182	**0.00005**	0.004	0.004	0.005	0.005	**0.00005**	0.064	**0.0005**	**0.005**	**0.0005**	0.064	0.08	0.075	4.8
T02 - pH 12.0	29/03/2019	11.9	5	2.37	**0.0005**	0.007	0.144	**0.00005**	0.001	0.002	0.003	0.061	**0.00005**	0.037	**0.0005**	**0.005**	**0.0005**	0.002	0.06	0.196	0.5
T03 - pH 10.5	29/03/2019	10	6	4.33	**0.0005**	0.006	1.51	0.0003	0.013	0.017	0.127	2.35	**0.00005**	0.01	0.012	**0.005**	**0.0005**	0.006	0.28	0.291	0.6
T04 - pH 9.0	23/04/2019	9.09	**0.5**	0.02	**0.0005**	**0.0005**	0.158	0.0001	**0.0005**	0.004	0.001	0.054	**0.00005**	0.024	**0.0005**	**0.005**	**0.0005**	0.002	**0.025**	0.019	0.6
T05 - pH 8	23/04/2019	8.1	**0.5**	0.02	**0.0005**	**0.0005**	0.483	**0.00005**	**0.0005**	0.004	**0.0005**	0.034	**0.00005**	0.02	**0.0005**	**0.005**	**0.0005**	0.002	**0.025**	0.167	0.6
T06 - pH Neutral	29/03/2019	6.44	6	0.03	**0.0005**	**0.0005**	1.38	0.0004	**0.0005**	0.004	**0.0005**	1.03	**0.00005**	**0.0005**	0.005	**0.005**	**0.0005**	**0.0005**	0.18	0.585	0.3
T07 - pH 5.5	23/04/2019	5.63	**0.5**	0.01	**0.0005**	**0.0005**	1.04	0.0004	**0.0005**	0.004	**0.0005**	2.4	**0.00005**	**0.0005**	0.012	**0.005**	**0.0005**	**0.0005**	0.07	0.689	0.2
T08 - pH 4	23/04/2019	3.52	**0.5**	4.39	**0.0005**	0.004	5.18	0.0033	0.006	0.03	0.014	13.3	**0.00005**	**0.0005**	0.045	**0.005**	**0.0005**	0.023	0.34	1.21	1.2
T09 - pH 2.0	29/03/2019	1.96	5	19.5	**0.0005**	0.034	13.8	0.0042	0.08	0.198	1.04	35	**0.00005**	**0.0005**	0.08	0.04	**0.0005**	0.265	0.53	1.58	1
B01 - Neutral	29/03/2019	6.64	**0.5**	0.01	**0.0005**	**0.0005**	0.088	**0.00005**	**0.0005**	**0.0005**	**0.0005**	0.014	**0.00005**	**0.0005**	**0.0005**	**0.005**	**0.0005**	**0.0005**	**0.025**	0.014	**0.05**
B02 - pH 2.0	29/03/2019	1.74	5	0.02	**0.0005**	**0.0005**	0.02	**0.00005**	**0.0005**	**0.0005**	0.002	0.009	**0.00005**	**0.0005**	**0.0005**	**0.005**	**0.0005**	**0.0005**	**0.025**	0.01	**0.05**
B03 - pH 13	29/03/2019	12.9	**0.5**	0.17	**0.0005**	**0.0005**	0.453	**0.00005**	**0.0005**	0.005	0.002	0.003	**0.00005**	0.002	**0.0005**	**0.005**	**0.0005**	**0.0005**	**0.025**	0.072	3.8
Hastings pilot plant filtrate	29/03/2019	11.8	182	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.6

NEPM Drinking Water = between trigger and 10X	NEPM Drinking Water = between trigger and 10X
NEPM Drinking Water = between 10X and 100X	NEPM Drinking Water = between 10X and 100X
NEPM Drinking Water = between 100X and 1000X	NEPM Drinking Water = between 100X and 1000X
NEPM Drinking Water = >1000X	NEPM Drinking Water = >1000X

Bold values are half the detection limit

Appendix 4: Air emissions addendum information

PART A – ERM 2019 results of ABK predicted ground level concentration impacts

Table 41: ERM 2019 modelled results at off site receptors for the Acid Bake Kiln (start-up, normal and emergency conditions)

Pollutant	Averaging Period	Assessment Criteria	Start-up			Normal			Emergency		
			Accommodation Camp	Gifford Creek Homestead	Edmund Homestead	Accommodation Camp	Gifford Creek Homestead	Edmund Homestead	Accommodation Camp	Gifford Creek Homestead	Edmund Homestead
H_2SO_4	3 minute	33 µg/m³	1.0	0.5	0.3	1.3	0.6	0.4	35.0[1]	14.9[1]	8.4[1]
	1 hour	18 µg/m³	0.3	0.1	0.1	0.4	0.2	0.1	10.6[1]	4.5[1]	2.5[1]
SO_2	10 minute	712 µg/m³	9.2	4.3	2.5	11.3	5.6	3.5	2.7	1.2	0.7
	1 hour	196 µg/m³	4.5	2.1	1.2	5.5	2.7	1.7	1.3	0.6	0.3
	24 hour	52 µg/m³	0.8	0.4	0.4	1.1	0.5	0.6	0.2	0.1	0.1
HF	24 hour	2.9 µg/m³	0.1	0.03	0.03	0.1	0.03	0.04	0.049	0.03	0.03
PM_{10}	24 hour	50 µg/m³	19.1	19.1	19.1	19.1	19.1	19.1	n/a	n/a	n/a
	Annual	25 µg/m³	17.0	17.0	17.0	17.0	17.0	17.0	n/a	n/a	n/a
CO	8 hour	10,300 µg/m³	44.7	19.7	19.0	39.9	17.9	16.9	41.4	17.6	17.5

Note:

1. Calculations have been updated following a referencing error in for scaling factor identified in the original plume study (ERM, 2018)
2. Text highlighted in red denotes values that exceed criteria. This scenario was also selected for the presentation of contours
3. Text highlighted in blue represents the model scenario selected for presenting contours as they represent the most restrictive scenario for the criteria under assessment

Table 42: ERM 2019 modelled results at off site receptors for the Acid Bake Kiln (upset conditions)

Pollutant	Averaging Period	Assessment Criteria	Upset (WESP On)			Upset (WESP Off)		
			Accommodation Camp	Gifford Creek Homestead	Edmund Homestead	Accommodation Camp	Gifford Creek Homestead	Edmund Homestead
H_2SO_4	3 minute	33 µg/m^3	1.0	0.5	0.3	32.0	14.9	8.6
	1 hour	18 µg/m^3	0.3	0.1	0.1	9.6	4.5	2.6
SO_2	10 minute	712 µg/m^3	9.2	4.3	2.5	2.5	1.2	0.7
	1 hour	196 µg/m^3	4.5	2.1	1.2	1.2	0.6	0.3
	24 hour	52 µg/m^3	0.8	0.4	0.4	0.2	0.1	0.1
HF	24 hour	2.9 µg/m^3	0.1	0.03	0.03	0.05	0.03	0.03
PM_{10}	24 hour	50 µg/m^3	19.1	19.1	19.1	n/a	n/a	n/a
	Annual	25 µg/m^3	17.0	17.0	17.0	n/a	n/a	n/a
CO	8 hour	10,300 µg/m^3	44.7	19.7	19.0	44.7	19.7	19.0

Note:

1. Text highlighted in blue represents the model scenario selected for presenting contours as they represent the most restrictive scenario for the criteria under assessment

Note: Assessment criteria sources are provided in section 11.5.4.

Part B – ERM 2019 model input stack concentrations and emission rates for the ABK

Table 43: Modelled in stack concentrations and emission rates for the ABK under normal conditions

Pollutant	In Stack Concentration (mg/Nm^3)		Emission Rate (g/s)	
	ABK Scrubber Stack	SAP Stack	ABK Scrubber Stack	SAP Stack
SO_2	801[a]	801[a]	8.3	2.4
H_2SO_4	45 [b]	45 [b]	0.57	0.17
HF	50	-	0.52	-
PM_{10}	100	-	1.04	-
NO_x	-	200	-	0.61
CO	10,000	-	103.61	-

Source: (Hastings, 2019a), (Hastings, 2019b)
a. Normalised conditions – Dry, 273K, 101.3 kPa.
b. reported as SO_3 equivalent

Table 44: Modelled in stack concentrations and emission rates for the ABK under start-up conditions

Pollutant	In Stack Concentration (mg/Nm^3) [a]	Emission Rate (g/s)
SO_2	801[a]	6
H_2SO_4	45 [b]	0.41
HF	50	0.38
PM_{10}	100	0.75
CO	15,000	112.90

Source: (Hastings, 2019a; Hastings, 2019b)
a. Normalised conditions – Dry, 273K, 101.3 kPa.
b. reported as SO_3 equivalent

Table 45: Modelled in stack emission rates for the ABK during emergency operations

Pollutant	Emission Rate (g/s)	
	ABK Scrubber Stack	
SO_2	1.6 [a]	
H_2SO_4	13 [b]	
HF	0.36 [c]	
NO_x	-	
CO	102.22 [e]	

a. Highest rolling 1 hour average emission rate of SO_2 for ABK during emergency shutdown (Hastings, 2018a)

b. Highest rolling 1 hour average concentration of SO_3 for ABK during emergency shutdown – converted to H_2SO_4 (Hastings, 2018a)

c. Highest HF concentration provided for ABK during emergency shutdown (Hastings, 2018a)

d. Hourly average concentration based on a release for only 60 seconds during emergency operations (Hastings , 2018b)

e. Calculated from emissions of 23g/Nm^3 (Hastings, 2019b)

Table 46: Modelled in stack emission rates for the ABK during upset conditions

Pollutant	WESP on (g/s)	WESP off (g/s)
SO_2	6	1.6 [a]
H_2SO_4	0.41	13.0 [a]
HF	0.38	0.4
CO	112.90	112.90

Source: (Hastings, 2019a; Hastings, 2019b)

Hourly average concentration based on a release for only 60 seconds during emergency operations (Hastings , 2018b)

Part C -

The following extracts from ERM 2019 summarise the findings of modelling BK emissions and their predicted ground level concentrations at receptors in comparison to assessment criteria. Note that the Accommodation camp is not considered a receptor for the purposes of this assessment. ERM 2019 notes that concentrations presented are from project emissions in isolation of background, however PM_{10} concentrations are cumulative (including background).

- H_2SO_4
  - Generally higher concentrations are predicted under emergency scenario
  - Under emergency operating conditions
    - Exceedances of 3-minute averages are predicted to occur at the Accommodation camp;
    - 3-minute average criteria is met at other discrete sensitive receptors;
    - Across all three sensitive receptors, the maximum 1-hour concentrations predicted is within criteria (~60% of criteria).
  - Contours for 3-minute and 1-hour average under emergency operating conditions are presented in Figure 5-1 and Figure 5-2 respectively.
- SO_2
  - Across all averaging periods considered, higher concentrations are predicted under normal operations
  - Across all discrete sensitive receptors and averaging periods, the maximum concentration predicted is about 3% of the relevant criteria
  - Contours for 10-minute, 1-hour and 24-hour average under normal operating conditions are presented in Figure 5-3, Figure 5-4 and Figure 5-5 respectively.
- HF
  - Across all averaging periods considered, higher concentrations are predicted under normal operations
  - The maximum concentrations predicted are about 2% of the relevant criteria
  - Contours for 24-hour average for normal operations are presented in Figure 5-6.
- PM_{10}
  - Across all averaging periods considered, higher concentrations are predicted under normal operations
  - Excluding background, the maximum concentrations predicted are about 0.04% of the criteria
  - Including background, the maximum concentrations predicted are about 68.04% of the criteria
  - Figure 5-7 and Figure 5-8 detail the 24-hour and annual average contours from normal operations at the ABK.

- CO
  - Across all averaging periods considered, higher concentrations are predicted under Start-up and Upset conditions
  - The maximum concentrations predicted are less than 0.4% of the relevant criteria
  - Contours for Start-up and Upset (WESP Off) conditions are presented in Figure 5-9 and Figure 5-10 respectively.

Part D – Process flow diagram of the ABK normal and emergency off-gas scrubbing systems

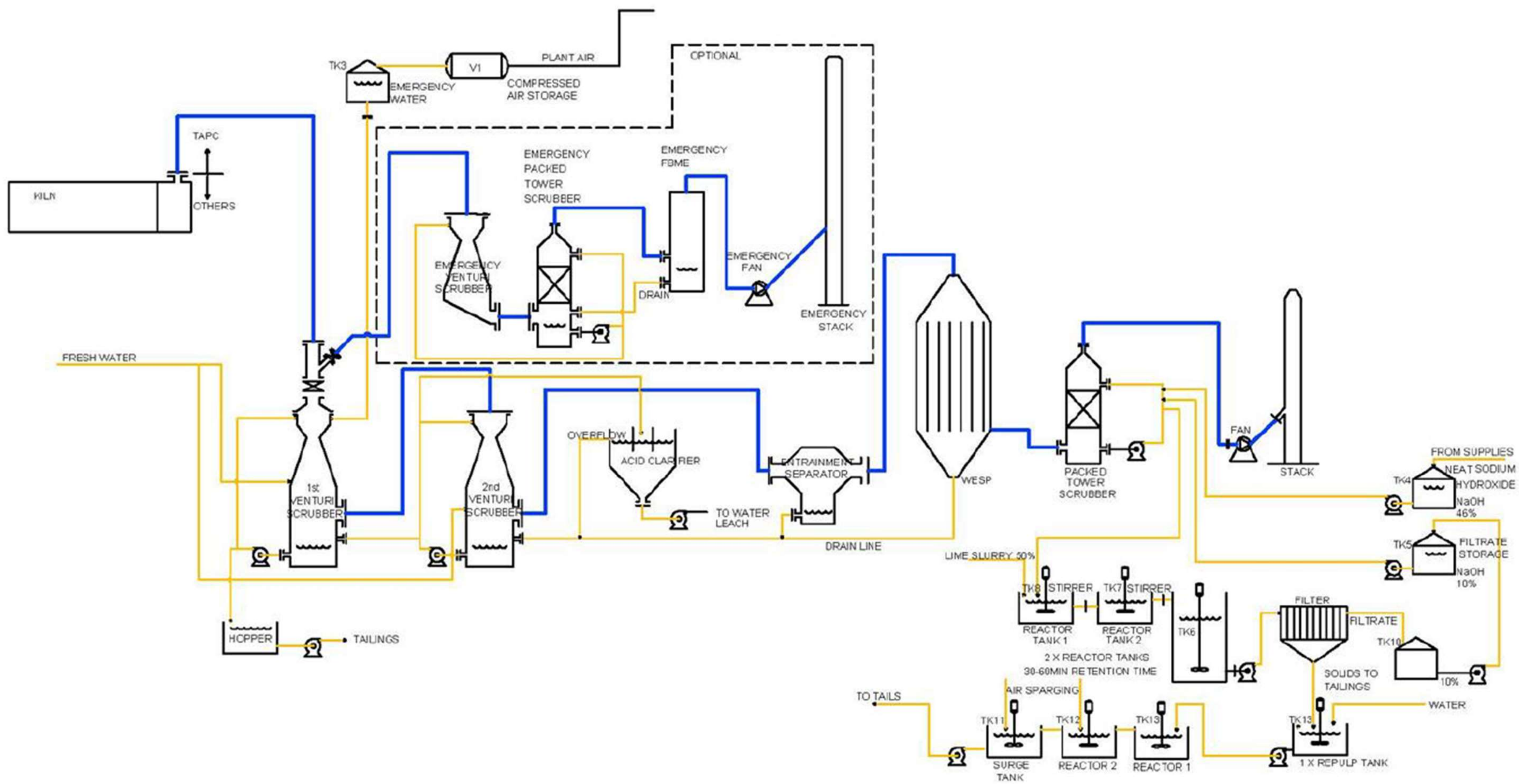


Figure 16: Process flow diagram of the ABK off gas scrubbing plant process train (Source: Application)

Attachment 1: Granted Works Approval W6209/2019/1