Yangibana Rare Earths Project

Environmental Review Document

30 January 2017

	Document Status			
Rev	Author	Reviewer	Approved	Date
A	Lara Jefferson	OEPA prelim. review		05/01/17
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0	Lara Jefferson		Charles Tan	30/01/17
1	Lara Jefferson		Charles Tan	09/02/17

1 .EXECUTIVE SUMMARY

Hastings Technology Metals Limited (Hastings) proposes to develop the Yangibana Rare Earths Project (the Proposal; Table 2), located in the Upper Gascoyne region of Western Australia (WA; Figure 1).

Table ES-1 Summary of the Proposal

Proposal Title	Yangibana Rare Earths Project
Proponent Name	Hastings Technology Metals Limited
Short Description	Hastings Technology Metals Limited (Hastings) proposes to develop the Yangibana Rare Earths Project (the Proposal), located approximately 270 km east-northeast of Carnarvon, in the Upper Gascoyne region of Western Australia (WA). The Proposal will involve mining above and below the ground water table, on-site processing of ore, water abstraction, and transport via road to Geraldton port for export.

REE will be mined from four deposits. During mining the REE ore will be taken to the ROM pad in preparation for processing, whereas waste rock will be deposited in a waste rock landform, alongside each respective pit. A processing plant, consisting of a beneficiation process and a hydrometallurgical process, will produce a REE concentrate product. Tailings will be disposed in three TSFs. Support infrastructure will include, but is not limited to, power, water, accommodation facilities, airstrip and linear infrastructure.

Table 3 provides a summary of the location and proposed extent of physical and operational elements of the Proposal.

Table ES-2 Location and proposed extent of physical and operational elements

Element	Location	Proposed Extent
Physical elements		
Mine and associated infrastructure	Figure 2	Clearing of no more than 1,000 Ha within a development envelope of 12,098 Ha
Operational elements		
Mining	Figure 2	Mining from 4 pits
Water abstraction, including dewatering from pits	Figure 2	Abstraction of no more than 2.5 GL/a of groundwater
Ore processing (waste)	Figure 2	Tailings disposal of no more than: • 6.545 Mt into TSF1 • 280,000 t into TSF2 • 420,000 t into TSF3

Transport	Figure 1	Transport of packaged product to port via trucks on existing roads. Storage of packaged product at an existing port facility. Loading of product on existing container ships.

Hastings has consulted with the following key stakeholders:

1. Commonwealth government:
- Department of the Environment and Energy (DoEE)
2. State Government:
- Department of Mines and Petroleum (DMP)
- Radiological Council
- Department of Environment Regulation (DER)
- Department of Water (DoW)
3. Native Title Holders
- combined Tiin-Mah Warriyangka, Tharrkari, Jiwarli native title claimants (WC2016/003; WAD464/2016)
4. Pastoralist
- Bagden Pty Limited, Wanna and Gifford Creek Stations

Section 4A of the *Environmental Protection Act 1986* (WA; EP Act) describes the principles of environmentally sustainable development. These principles have been considered in the context of the Proposal. Environmental impact assessment of five key environmental factors is summarised in Table ES-3.

Table ES-3 Summary of the environmental review

Key Environmental Factor 1: Flora and vegetation	
EPA objective	*To protect flora and vegetation so that biological diversity and ecological integrity are maintained.*
Policy and guidance	Laws and regulations relevant to the consideration of flora and vegetation include: *Agricultural and Related Resources Protection Act 1976* (WA) *Biosecurity and Agriculture Management Act 2007* (WA) *Bush Fires Act 1954* (WA) *Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth) *Environmental Protection Act 1986* (WA) *Wildlife Conservation Act 1950* (WA)

	Relevant guidelines include: EPA (2000) Position Statement No. 2: Protection of native vegetation in Western Australia; EPA (2002) Position Statement No. 3: Terrestrial biological surveys as an element of biodiversity protection; EPA (2003) Guidance Statement 55: Implementing best practice in proposals submitted to the environment impact assessment process; EPA (2004) Guidance Statement No. 51: Terrestrial flora and vegetation surveys for environmental impact assessments in Western Australia; EPA (2016n) Technical Guidance - Flora and vegetation surveys for environmental impact assessment; and EPA (2016e) Environmental Factor Guideline: Flora and vegetation
Potential impacts	• Clearing approximately 1,000 Ha of native vegetation. • Clearing beyond approved footprint. • Direct loss of Priority flora species. • Increased fire hazards as a result of mine site activities resulting in potential for fire to temporarily impact vegetation. It should be noted that this may positively impact some flora species. • Changes to surface and groundwater quality potentially impacting vegetation. • Altered surface water flow during heavy rainfall events impacting vegetation downstream. • Introduction, establishment and spread of weed species. • Indirect impacts of dust from vehicle movements. • Indirect impacts from uptake of radionuclides.
Mitigation	**AVOID** • Avoid clearing populations of conservation significant species, where possible. • 150 m exclusion zone on either side of Fraser Creek and Lyons River. **MINIMISE** • Groundwater abstraction from fractured rock aquifers is self-limiting. • Water reuse to reduce the water requirements of the Proposal. • Topsoil stockpile management to retain viability of local provenance native seedbank.

	• Flora and vegetation management plan, including:
	  ○ management of existing weeds and prevention of the introduction and establishment of weed species (not currently present in the development envelope);
	  ○ ground disturbance procedure to ensure delineation of clearing boundaries and topsoil management;
	  ○ dust suppression; and
	  ○ fire prevention, with reference to bush fire management procedures in the Emergency Response Plan.
	REHABILITATION
	• Progressive rehabilitation implemented as determined in the Preliminary Mine Closure Plan.

Outcomes	**RESIDUAL IMPACT** Direct impact to two priority flora species is considered insignificant: Only 1 % and 3 % of *Acacia curryana* and *Rhodanthe frenchii* plants, respectively, will be disturbed within the study area. **OFFSETS** No offsets are required.
Key Environmental Factor 2: Subterranean fauna	
EPA objective	*To protect subterranean fauna so that biological diversity and ecological integrity are maintained.*
Policy and guidance	Laws and regulations relevant to the consideration of subterranean fauna include: *Environmental Protection Act 1986* (WA) Relevant guidelines include: EPA (2002) Protection Position Statement No. 3: Terrestrial biological surveys as an element of biodiversity; EPA (2007) Guidance Statement No. 54A: Sampling methods and survey considerations for subterranean Fauna in Western Australia (Technical Appendix to GS 54); EPA (2013) Environmental Assessment Guideline (EAG 12): Consideration of subterranean fauna in environmental impact assessment in Western Australia; EPA (2016k) Environmental Factor Guideline: Subterranean fauna; and EPA (2016o) Technical Guidance - Subterranean fauna survey.
Potential impacts	• Direct loss of subterranean fauna species and associated habitat from mining.

	• Potential indirect and temporary impacts to habitat in the immediate vicinity of pit dewatering activities. • Potential indirect impacts to PEC habitat as a result of changes to surface and groundwater quality
Mitigation	**AVOID** • No groundwater abstraction from the Gifford Creek calcrete aquifers. • No significant groundwater abstraction from an aquifer with direct hydraulic connection to the Gifford Creek Calcrete PEC. **MINIMISE** • Limit groundwater abstraction to meet operation requirements only. • Water collection and re-use from processing plant, where possible. • Processing plant, evaporation pond and tailings storage facility (TSF) located outside of the flood plain. • Containment and secondary bunding around all facilities with chemicals and hazardous waste. • Surface water management at the process plant, evaporation pond and TSF, including: ○ the evaporation pond, and appropriate collection bunds and channels will be used to manage potentially contaminated surface water runoff; ○ the containment of surface water runoff, associated with a significant rainfall event, around the ROM, processing plant and TSF 2 and 3; and ○ maintaining adequate freeboards to manage unforeseen events. • Spill management procedures. • Implement the Radiation Waste Management Plan (Appendix 5-7). • Surface water and groundwater monitoring. **REHABILITATE** • Cessation of water abstraction activities at closure will result in the rebound of the water table towards pre-mining levels, reintroduction of natural geohydrology patterns and return of subterranean fauna habitat.
Outcomes	**RESIDUAL IMPACT** Loss of 101.5 Ha of subterranean fauna habitat will occur as a result of mining. This represents less than 0.05% of the Gifford Creek PEC footprint.

	<u>OFFSETS</u> No offsets are required.
Key Environmental Factor 3: Terrestrial environmental quality	
EPA objective	*To maintain the quality of land and soils so that environmental values are protected.*
Policy and guidance	Laws and regulations relevant to the consideration of terrestrial environment quality include: *Australian Radiation Protection and Nuclear Safety Act 1998* (Commonwealth) *Contaminated Sites Act 2003* (WA) *Dangerous Goods and Safety Act 2004* (WA) *Environmental Protection Act 1986* (WA) *Health Act 1911 (WA)* *Mines Safety and Inspection Act 1994* (WA) *Mining Act 1950* (WA) *Radiation Safety Act 1975 (WA)* *Soil and Land Conservation Act 1945 (WA)* Relevant guidelines include: ANCOLD (2012) Guidelines on Tailings Dams - Planning, Design, Construction, Operation and Closure; ANCOLD (2012) Guidelines on the Consequence Categories for Dams; ARPANSA (2005) Code of Practice for Radiation Protection and Radioactive Waste Management in Mining and Mineral Processing (the Mining Code); Australian Government Department of Industry, Tourism and Resources (2007) Tailings Management: Handbook in the Leading Practice Sustainable Development Program for the Mining Industry Series; DER (2014) Assessment and Management of Contaminated Sites: Contaminated Sites Guidelines; DMP (1998; prev. DME) Guidelines on the Development of an Operating Manual for Tailings Storage; DMP (2010) Managing naturally occurring radioactive material (NORM) in mining and mineral processing guideline (2nd edition). NORM 4.1 Controlling NORM – dust control strategies; DMP (2010) Managing naturally occurring radioactive material (NORM) in mining and mineral processing guideline (2nd edition). NORM-4.2 Controlling NORM – management of

	radioactive waste. Resources Safety, Department of Mines and Petroleum; DMP (2013) Code of Practice - Tailings storage facilities in Western Australia. Resources Safety and Environment Divisions; DMP (2013) Guidelines on the Safe Design and Operating Standards for Tailings Storage; DMP (2015) Guide to the Preparation of a Design Report for Tailings Storage Facilities; DMP and EPA (2015) Guidelines for Preparing Preliminary Mine Closure Plans; DoW (2009) Water quality monitoring program design: A guideline for field sampling for surface water quality monitoring programs; EPA (2003) Guidance Statement 55 - Implementing best practice in proposals submitted to the environment impact assessment process; EPA (2006) Guidance for the Assessment of Environmental Factors No. 6 – Rehabilitation of Terrestrial Ecosystems; EPA (2016l) Environmental Factor Guideline: Terrestrial Environmental Quality; and IAEA (2006) Storage of Radioactive Waste: Safety Guide.

Potential impacts	• Potential dispersion of saline, sodic and alkaline soils associated with disturbance of plains soils.
	• Potential contamination of surrounding soil and land as a result of:
	    ○ Potential dust generation from ROM pad, processing plant and TSFs.
	    ○ Seepage of tailings water.
	    ○ Potential operational leaks and spills.
	    ○ Contaminated surface water.
	    ○ Potential failure of TSF integrity.
	• Potential erosion of waste rock landform (WRL) surfaces.

Mitigation	**<u>Avoid</u>** • On-going characterisation and management of waste rock to ensure erosive and elevated radionuclide materials are not used on surface slopes of waste rock landforms. • Avoid using plains topsoils as a growth medium for rehabilitation of disturbed areas. • Location of processing plant, evaporation pond and TSFs outside of the flood plain.

	<u>**MINIMISE**</u>
	• Minimise dust generation using water sprays, where possible.
	• Minimise potential for spills through personnel training and awareness.
	• Surface water management structures will be designed and constructed to minimise erosion
	• Diversion drains will be constructed to ensure water re-enters natural drainage lines at a velocity and depth that can be accommodated by the natural stream line without increased scouring.
	• Contractor management, including:
	    • Environmental compliance requirements in contracts.
	    • Environmental Specification for Contractors (to be developed) will include:
	        ▪ requirement for site-specific and activity-specific EMP;
	        ▪ roles and responsibilities;
	        ▪ provision of Hastings relevant management plans, procedures, licence conditions;
	        ▪ provision of Hastings environmental policy;
	        ▪ ensuring each contractor has adequate resourcing for environmental management of their activities relative to the level of risk;
	        ▪ requirement for activity based and task specific environmental risk assessment; and
	        ▪ environmental performance reporting requirements.
	    • Coordination of waste segregation, recycling and management.
	    • Training and awareness.
	    • Audits and inspections.
	• Radiation Waste Management Plan
	• Land Management Plan (to be developed) will include the following considerations:
	    • Application of waste management hierarchy.
	    • Containment bunding, silt and oil traps will be established where necessary to remove sediments or pollutants from runoff before water enters local drainage.
	    • Spill clean-up procedures

	• Visual monitoring will be undertaken of diversion channels and downstream drainage lines, and the condition of vegetation in the diversion channels. • Reference to water quality monitoring in a Water Management Plan (to be developed). • Visual monitoring of dust generation • Contingency measures for excessive dust generation • Waste management for general domestic and office waste, industrial waste, landfill, hydrocarbons, tyres, and sewage. • Management measures for dangerous goods and hazardous materials. • Hazard and incident reporting. • Pastoral activities and associated protocols. • Reference to procedures in the Cultural Heritage Management Plan (in draft). • Waste Rock Management Plan (to be developed) will include the following considerations: • waste rock characterisation and segregation program during operations; • use of saprolites, pegmatites and other clay rich lithologies for TSF embankment lifts and low infiltration covers; • WRL batters to consist only of benign, competent durable fresh waste rock; • use of concave slopes on WRLs to reduce potential for erosion; and • waste rock with elevated radionuclide levels is to be distributed/diluted with waste rock containing low radionuclide levels in the WRL. **REHABILITATE** Rehabilitation of waste facilities as per the Preliminary Mine Closure Plan.
Outcomes	**RESIDUAL IMPACT** TSF 2 and 3 will likely be listed as contaminated sites under the *Contaminated Sites Act 2003* (WA) due to the storage and containment of tailings with elevated radionuclides. This represents an area of approximately 20 Ha. **OFFSETS** No offsets are required.

Key Environmental Factor 4: Inland waters environmental quality	
EPA objective	*To maintain the quality of groundwater and surface water so that environmental values are protected.*
Policy and guidance	Laws and regulations relevant to the consideration of inland waters environmental quality include: *Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth) *Mining Act 1950* (WA) *Rights in Water and Irrigation Act 1914* (WA) *Waterways Conservation Act 1976 (WA)* Waterways Conservation Regulations 1981 (WA) Relevant guidelines include: ANZECC and ARMCANZ (2000) Australian and New Zealand guidelines for fresh and marine water quality; DMP and EPA (2015) Guidelines for Preparing Mine Closure Plans; DoW (2009a). Hydrogeological reporting associated with a groundwater well licence; DoW (2009b) Water quality monitoring program design: A guideline for field sampling for surface water quality monitoring programs; DoW (2011) Use of operating strategies in the water licencing process; DoW (2013a) Western Australian Water in Mining Guideline; DoW (2013b) Use of mine dewatering surplus; DoH (2013) System compliance and routine reporting requirements for small community water providers; EPA (2003) Guidance Statement 55 - Implementing best practice in proposals submitted to the environment impact assessment process; EPA (2004d) Position Statement No. 4: Environmental protection of wetlands; EPA (2016h) Environmental Factor Guideline: Inland waters environmental quality; Johnson and Wright (2003) Mine void water resource issues in Western Australia, Hydrogeological Record Series HG9; NHMRC and ARMCANZ (1996). Australian drinking water guidelines; and WRC (2000) Water Protection Guidelines No. 11 Mining and Mineral Processing: Mine dewatering.

Potential impacts	• Increased sediment load to drainage lines from the presence of the Proposal. • Surface water contamination from processing reagents, chemicals and hydrocarbons. • Surface water / groundwater contamination from process liquor in the decant pond and evaporation pond. • Biological contamination to surface water / groundwater from the sewage treatment plant(s). • Groundwater contamination from landfill leachate, tailings seepage, and drainage from waste rock landforms. • Final void pit lakes may increase in salinity over time and not satisfy the intended post-mining land use.

Mitigation	**AVOID**
	• Exclusion of disturbance within 150 metres of Yangibana and Fraser's Creeks, with the exception of road crossings.
	• Locate soil stockpiles away from drainage lines and flood zones and up-gradient of potential contaminating landforms and activities.
	• Design the Proposal layout so that mining landforms are located outside the Yangibana and Fraser's Creeks flood zones.
	• Exclusion of groundwater abstraction from calcrete aquifers.
	MINIMISE
	• Design and locate infrastructure to minimise potential impacts associated with flood events.
	• Design and construct surface water management structures to:
	    • divert overland flows around mining landforms to minimise erosion and sedimentation,
	    • ensure linear infrastructure does not result in erosion and sedimentation,
	    • protect the processing plant, evaporation pond and tailings storage facilities from surface water flows during heavy rainfall events, and
	    • manage contaminated surface water runoff within processing plant, evaporation pond and tailings storage facility areas.
	• Radiation Waste Management Plan
	• Water Supply Operating Strategy (to be developed for 5C licence).
	• TSF Operating Manual including:
	    • short and long term range of readings that are anticipated for all monitoring instruments, monitoring bores, underdrain flows, and open channel flows, throughout the life of the TSF; and

	- actions to be followed in the event that readings are recorded outside an anticipated envelope of measurements should be stipulated in the Operating Manual. - Drinking Water Quality Management Plan (to be developed) - Water Management Plan (to be developed) to summarise and describe inter-relationships of water quality management and monitoring actions determined by the: - RWMP, - Water Supply Operating Strategy, - TSF Operating Manual, and - Drinking Water Quality Management Plan, and - ensure any gaps not covered in the above plans are addressed. **<u>Rehabilitate</u>** - Natural surface drainage to be considered post-closure; and - Bunding to prevent erosion of landforms post-closure.
Outcomes	**<u>Residual Impact</u>** The above mitigation will ensure potential impacts are unlikely to occur thus satisfying the EPA objective for this key environmental factor. **<u>Offsets</u>** No offsets are required.
Key Environmental Factor 5: Human health	
EPA objective	*To protect human health from significant harm.*
Policy and guidance	Laws and regulations relevant to the consideration of human health include: *Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth) *Mines Safety and Inspection Act 1994* (WA) *Occupational Safety and Health Act 1984 (WA)* *Radiation Safety Act 1975* (WA) Relevant guidelines include: ARPANSA (2005) Code of practice & safety guide: Radiation protection and radioactive waste management in mining and mineral processing; known as “the Mining Code”; ARPANSA (2008) Safety guide: Management of naturally occurring radioactive material; ARPANSA (2014a) Fundamentals: Protection against ionising radiation;

	ARPANSA (2014b) The code: Safe transport of radioactive material; DMP (2010) Managing naturally occurring radioactive material (NORM) in mining and mineral processing - guideline (2nd edition); EPA (2016f) Environmental Factor Guideline: Human health; IAEA (2003) Radiation protection against radon in workplaces other than mines; IAEA (2006) Assessing the need for radiation protection measures in work involving minerals and raw materials; IAEA (2010) Handbook of parameter values for the prediction of radionuclide transfer in terrestrial and freshwater environments; and ICRP (2014) Protection of the environment under different exposure situations.
Potential impacts	The potential impact of radiation exposure to humans occurs via four main exposure pathways: • Gamma irradiation. • Inhalation of radon decay products (RnDP) and thoron decay products (TnDP). • Inhalation of radionuclides in dust. • Ingestion of animals or plants that have come in contact with emissions.
Mitigation	**<u>Avoid</u>** • Processing extracts radionuclides to levels in the product not considered 'radioactive' thus avoiding risk along the transport route. • Location of infrastructure to avoid impacts to sensitive receptors. **<u>Minimise</u>** • Maintain a wet process and TSF 2 and 3 maintained as 'wet' (operational water cover) to minimise dust emissions. • Design of processing plant and TSF 2 and 3 to minimise the potential to impact sensitive receptors from dust emissions. • Design of the processing plant to minimise exposure to gamma radiation. • The Radiation Management Plan (Appendix 5-8) is the primary document for the management and monitoring of potential radiation impacts to human health and safety and will form a component of the Safety Management System. • The Radiation Waste Management Plan (Appendix 5-7) is the primary document for the management and monitoring of

	potential radiation impacts to the surrounding environment and will form a component of the Environmental Management System. **<u>Rehabilitate</u>** All post-mining land surfaces will have radiation levels equivalent to the Proposal baseline levels determined prior to implementation of the Proposal.
Outcomes	**<u>Residual Impact</u>** Taking into account the 'system of dose limitation', the predicted outcomes are discussed in context of the three key elements as follows: • Justification – naturally occurring radionuclides are associated with the target rare earths ore body. During processing they become concentrated in two of the three tailings streams. • Optimisation – exposure to doses are reduced to As Low As Reasonably Achievable (ALARA) with mitigation. • Limitation – the impact assessment determined that doses will not exceed the prescribed dose limits for the workforce or members of the public. Monitoring during operations will confirm and verify this information. A precautionary approach will be maintained commensurate with the level of risk. As a result of the application of the 'system of dose limitation', the EPAs objective will be achieved. **<u>Offsets</u>** No offsets are required.

Consideration of other environmental factors in this environmental impact assessment include:

- Landforms
- Terrestrial fauna
- Hydrological processes
- Air quality
- Social surroundings

Laws and regulations relevant to the consideration of Matters of National Environmental Significance include:

- *Environment Protection and Biodiversity Conservation Act 1999* (C'th; EPBC Act)
- EPBC Regulations 2000 (C'th)

Relevant guidelines include:

- DEWHA (2009) Matters of National Environmental Significance. Significant impact guidelines 1.1 - Environment Protection and Biodiversity Conservation Act 1999

The *Environment Protection and Biodiversity Conservation Act 1999* (C'th; EPBC Act) provides for the protection of nationally and internationally significant flora, fauna, ecological communities and heritage places.

Based on environmental studies conducted to-date, there will be no potential impacts to Matters of National Environmental Significance protected by the EPBC Act, including:

- Listed threatened species and ecological communities;
- Listed migratory species;
- Wetlands of international importance;
- The Commonwealth marine environment;
- World Heritage properties; and
- National Heritage places.

Hastings has a high level of confidence that this conclusion will be met.

The proposal is defined as a “nuclear action” under the EPBC Act due to the establishment and operation of TSF2 and TSF3, which will be used for the disposal of tailings from the processing plant cleaner circuit and hydrometallurgical circuit, respectively. Potential impacts to the public, the surrounding environment and the workforce have been assessed through consideration of the above key environmental factors.

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2 Introduction

2.1 Purpose and scope

The purpose of this Environmental Review Document (ERD) is to provide supplementary information and accompanies the referral of the Proposal under section 38 of the *Environmental Protection Act 1986* (WA). Specifically, this ERD is structured to provide detailed information on:

- the Proposal description (section 3),
- stakeholder engagement (section 4),
- an assessment of the Proposal activities on the key environmental factors taking into consideration survey findings, relevant policies and guidelines, the EPAs objectives for the factor and assessing impacts and mitigation to determine a predicted outcome (section 5),
- consideration of other environmental factors (section 6),
- consideration of Matters of National Environmental Significance (section 7), and
- concludes with a holistic impact assessment (section 8).

This document has been prepared in accordance with the:

- Environmental Impact Assessment (Part IV Divisions 1 and 2) Administrative Procedures 2016 (EPA 2016a),
- Environmental Impact Assessment (Part IV Divisions 1 and 2) Procedures Manual 2016 (EPA 2016b), and
- requirements set out in the Environmental Protection Authority (EPA) "Instructions on how to prepare an Environmental Review Document".

2.2 Proponent

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2.3 Environmental impact assessment process

The Proposal may be considered a significant proposal requiring a formal environmental impact assessment under Part IV, Section 38 of the *Environmental Protection Act 1986* (WA). Therefore, referral of the Proposal is warranted for consideration of assessment by the EPA.

The proposal likely triggers a 'controlled action' under the *Environment Protection and Biodiversity Conservation Act 1999* (Cwth; EPBC Act).

Due to the recent release of the revised Administrative Procedures (13 December, 2016), a *Bilateral Agreement* (under section 45 of the EPBC Act) to assess the 'controlled action' by the EPA is currently not in place. Therefore, Hastings is seeking an *accredited* process for the purposes of assessment of the likely 'controlled action' by the EPA.

2.4 Other approvals and legislation

The Proposal is located within tenure granted under the *Mining Act 1978* (WA), comprising of exploration leases, mining leases and miscellaneous leases. Mining activities will occur within the following mining leases (M):

- M09/157
- M09/158
- M09/159
- M09/160
- M09/161
- M09/162

Some Miscellaneous Leases (L) and General Purpose Leases (G) have been obtained for associated infrastructure (e.g. processing plant, access and haul roads, camp, airstrip):

- L09/66
- L09/67

Other lease applications have been submitted and are pending approval:

- L09/78
- L09/79
- L09/80
- G09/13

- G09/14
- G09/16

Grants for additional tenure or conversion of tenure will be required in the future for waste rock landforms and other infrastructure.

Coexisting *Land Administration Act 1997* (WA) land tenure is pastoral lease, with the Proposal overlying Gifford Creek and Wanna Stations (both stations are owned by the same leaseholder, Bagden Pty Limited and were previously the one Wanna Station).

On the 7th of October, 2016, the combined Thin-Mah Warianga, Tharrikari, Jiwarli submitted a native title claim (WC2016/003) (WAD464/2016) over the Proposal area and beyond. Hastings will comply with the *Native Title Act 1993* (C'th) in relation to pending and future tenement applications.

Other approvals and legislation identified for this Proposal are listed in **Table 1**.

Table 1 Other approvals and regulation

Proposed activities	Land tenure/access	Type of approval	Legislation regulating the activity
Clearing of native vegetation	*Mining Act 1978:* all mining tenure	Native Vegetation Clearing Permit	*Environmental Protection Act 1986*
Mining	*Mining Act 1978*: Mining lease	Mining Proposal	*Mining Act 1978*
Closure and rehabilitation	*Mining Act 1978*: all mining tenure	Approval of Preliminary Mine Closure Plan	*Mining Act 1978*
Construction of well, water abstraction, dewatering	*Mining Act 1978*: Mining leases and miscellaneous leases	26D and 5C licenses	*Rights in Water and Irrigation Act 1914*
Handling of naturally occurring radioactive materials, radiation safety	*Mining Act 1978*: all mining tenure	Approval of Radiation Management Plan and Radiation Waste Management Plan	*Mines Safety and Inspection Act 1994* *Radiation Safety Act 1975*
Buildings	*Mining Act 1978*: all mining tenure	Building licenses	*Local Government Act 1995*
Construction and operation of prescribed waste premises i.e. processing facilities and associated tailings storage facilities, landfill, sewage treatment plant	*Mining Act 1978*: all mining tenure	Works Approvals and Operating Licenses	*Environmental Protection Act 1986*

3 Proposal

3.1 Background

The Proposal was referred to:

- the EPA on the 30th January, 2017, and
- the DoEE on the 15th December, 2016.

There have been no further modifications to the proposal since the time of referral.

3.2 Justification

There are no feasible alternatives to implementing this Proposal. Market demand for Rare Earth Elements (REE) is ever increasing as economies move towards 'green energy' technology. Specifically, the REE are used in permanent magnets, which in turn are used in medical technologies, amongst other popular items such as electric cars, wind turbines and mobile phones.

During the Pre-Feasibility Study an options study was undertaken with up to six locations and two designs considered for a TSF. The location of the processing plant and associated TSFs were guided by:

- location of the resource,
- methods of tailings handling and discharge (thickened vs. un-thickened),
- economics of ore haulage from four open pits located over approximately 7 km,
- geotechnical study outcomes for landform stability and seepage analysis,
- surface water drainage patterns,
- cultural heritage surveys,
- wind direction, and
- pastoralist consultation.

Disposal of all three tailings streams in one TSF has also been considered. However, radionuclide concentrations will still be elevated and thus require a higher level of management. Given that over 90% of tailings are benign and do not have elevated levels of radionuclides, the costs associated with disposal are significantly reduced if they are disposed in separate TSFs. This also significantly reduces the footprint of those TSFs with elevated levels of radionuclides.

Backfilling of the mine pits has also been considered. The target ore body continues at depth. The depth of the pits is based on economic considerations. Market demand for REE is predicted to increase in the future, therefore the depth at which the target resource can be mined may increase in the future. Backfilling will potentially sterilise future reserves.

Locations of linear infrastructure, the camp and airstrip have taken into consideration pastoral values and surface hydrology. The water levels of seasonal flood events, location of Gifford Creek homestead and future potential mining areas have been taken into account in the determination of road alignments. Land with high levels of pastoral value and future potential mining areas have resulted in changes to the location of the airstrip.

Reuse and optimisation of water usage in the processing plant has reduced water requirements for the Proposal. All water from pit dewatering will also be used in the processing plant reducing wastage associated with water disposal.

3.3 Proposal description

Hastings Technology Metals Limited (Hastings) proposes to develop the Yangibana Rare Earths Project (the Proposal; **Table 2**), located in the Upper Gascoyne region of Western Australia (WA; **Figure 1**).

Table 2 Summary of the Proposal

Proposal Title	Yangibana Rare Earths Project
Proponent Name	Hastings Technology Metals Limited
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Rare Earths Elements (REE) will be mined from four deposits (section 3.3.1). During mining the REE ore will be taken to the ROM pad in preparation for processing, whereas waste rock will be deposited in waste rock landforms, alongside each respective pit (section 3.3.2). A processing plant, consisting of a beneficiation process and a hydrometallurgical process, will produce a mixed rare earths carbonate product. Tailings will be disposed in three tailings storage facilities (TSFs; section 3.3.3). Support infrastructure will include, but is not limited to, power, water, accommodation facilities, airstrip and linear infrastructure (section 3.3.4). Trucks (i.e. two semi-trailer trucks every three days) will transport the product to Geraldton port via existing roads (section 3.3.4). The development envelope and indicative footprint are shown in **Figure 2**.

Table 3 provides a summary of the location and proposed extent of physical and operational elements of the Proposal.

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Element	Location	Proposed Extent
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Mine and associated infrastructure	Figure 2	Clearing of no more than 1,000 Ha within a development envelope of 12,098 Ha
Operational elements		
Mining	Figure 2	Mining from 4 pits
Water abstraction, including dewatering from pits	Figure 2	Abstraction of no more than 2.5 GL/a of groundwater
Ore processing (waste)	Figure 2	Tailings disposal of no more than: • 6.545 Mt into TSF1 • 280,000 t into TSF2 • 420,000 t into TSF3
Transport	Figure 1	Transport of packaged product to port via trucks on existing roads. Storage of packaged product at an existing port facility. Loading of product on existing container ships.

SCALE: 1:5,000,000 @ A4
COORDINATE SYSTEM: GDA 1994 MGA ZONE 50
PROJECTION: TRANSVERSE MERCATOR
DATUM: GDA 1994
UNITS: METER

ecoscape

PROJECT NO: 3402-15

REV	AUTHOR	APPROVED	DATE
0	SB	JN	13/12/2016

N

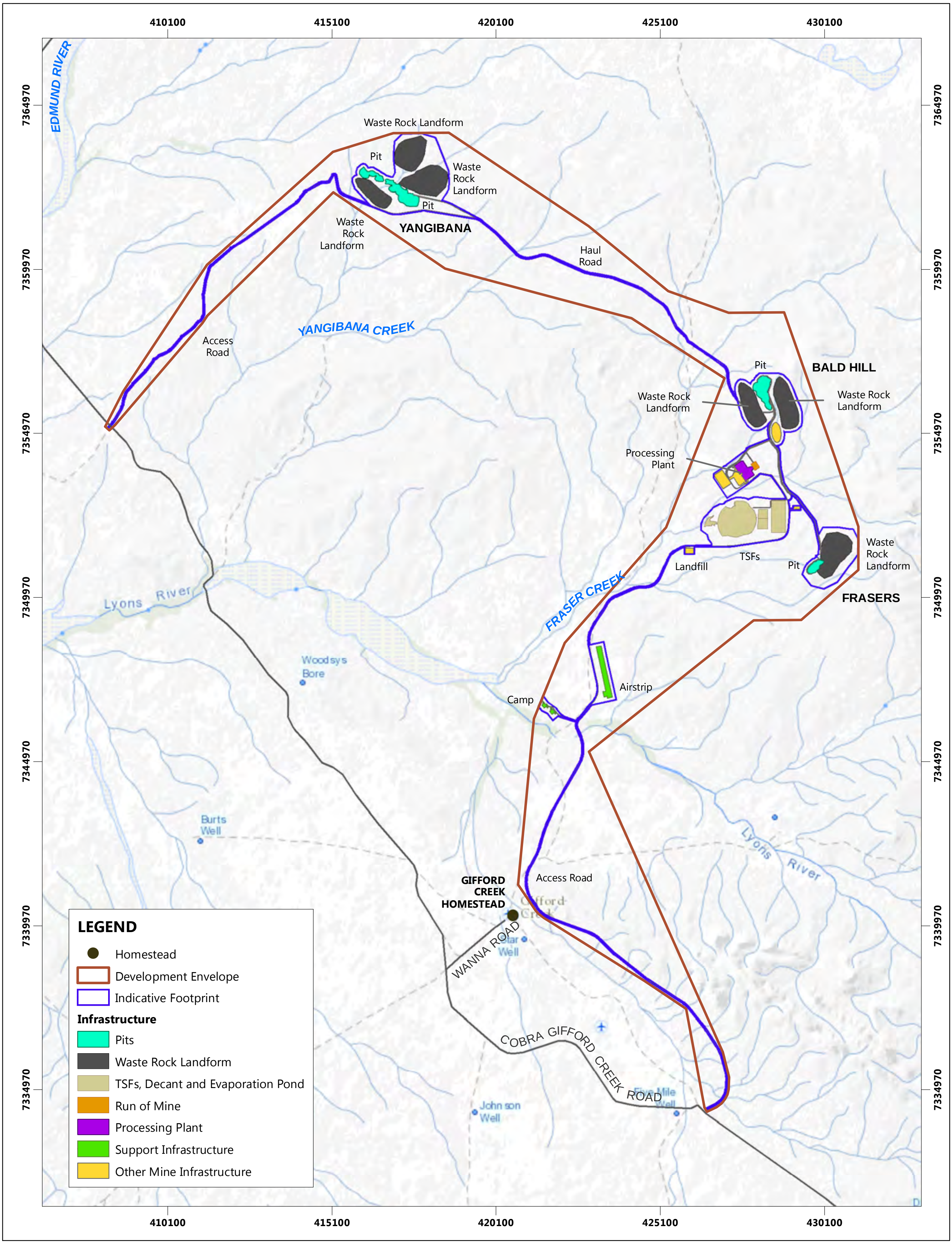
0 50 100 150 km

REGIONAL LOCATION OF THE PROPOSAL

YANGIBANA RARE EARTHS PROJECT

CLIENT: HASTINGS

FIGURE 01



SCALE: 1:150,000 @ A4

COORDINATE SYSTEM: GDA 1994 MGA ZONE 50
PROJECTION: TRANSVERSE MERCATOR
DATUM: GDA 1994
UNITS: METER

DATA SOURCES:
TOPOGRAPHIC LAYERS: GEOSCIENCE AUSTRALIA
SERVICE LAYERS: GEOSCIENCE AUSTRALIA

ecoscape

PROJECT NO: 3402-15

REV	AUTHOR	APPROVED	DATE
0	JN	ERR	17/01/2017

N

0 1 2 3 4 km

PROPOSAL DEVELOPMENT ENVELOPE AND INDICATIVE FOOTPRINT

YANGIBANA RARE EARTHS PROJECT

CLIENT: HASTINGS

FIGURE 02

3.3.1 Mineral resource

There are four deposits (Yangibana North, Yangibana West, Bald Hill and Fraser's) within the Proposal area containing economic quantities of rare earth elements (REE) in a monazite ore. The monazite is rich in REE, of which neodymium, praseodymium, dysprosium and europium are most valuable. These elements are primarily used in the industrial metals markets for the production of permanent magnets and advancing technologies in electric vehicles, wind turbines, robotics, and digital devices, to name a few.

3.3.2 Mining

The ore bodies will be mined using conventional open cut pit methods of drill and blast, load and haul. Proposed depths of open cut pits range from 70 metres below ground level (mBGL) at Bald Hill, and 95 mBGL at Yangibana and Fraser's. The largest deposit will be Yangibana, which comprises of Yangibana North and Yangibana West deposits.

Deposits will require dewatering prior to mining below the groundwater table. Depth to groundwater within deposits ranges from 6 mBGL to 30 mBGL.

Mine waste rock will be generated throughout the mining phase of operations. The strip ratio of ore to waste rock will vary depending on the deposit and the depth of mining, with more waste rock produced with depth. The average strip ratio for all four pits combined is 1:7. The proposed annual mining rate is approximately 8 million tonnes per annum (Mtpa), of which 1 Mtpa will be ore. Waste Rock Landforms (WRL) will be constructed adjacent to each open pit. WRLs will be reshaped during the rehabilitation phase of the operation to meet final landform design parameters. The proposed maximum height of WRLs is up to 30-40 metres above the natural surface.

3.3.3 Processing

3.3.3.1 Beneficiation

The initial phase of processing occurs within the beneficiation plant (**Figure 3**). This consists of conventional processes to remove economic materials and increase the REE concentrations. This process includes:

- Crushing circuit;
- Grinding in SAG mill and/or ball mill;
- Flotation circuit to produce a mineral concentrate; and
- A regrind mill.

The beneficiation mineral concentrate will represent approximately 3-5% of the incoming ore mass. The remaining 95-97% comprising barren material, which will be disposed of in Tailings Storage Facilities (TSFs). The majority of water used in the beneficiation process will be recovered and reused. The beneficiation concentrate will undergo further processing in the hydrometallurgical plant.

Key reagents used in the beneficiation process include:

- Sodium hydroxide;
- Sodium silicate; and
- Fatty acid collector.

3.3.3.2 Hydrometallurgy

The hydrometallurgical plant will continue processing the concentrate to remove residual materials such as iron, phosphate, aluminium, uranium and thorium (and their decay products) and produce a mixed rare earth carbonate. Approximately 12 - 13,000 tpa of mixed rare earth concentrate will be produced. The process includes:

- Acidification and roasting of the mineral concentrate to crack the mineral structure;
- Water leaching to bring metals into solution;
- Purification and ion exchange to remove impurities;
- Precipitation of rare earths carbonate product; and
- Neutralisation of waste streams prior to disposal in a TSF.

The key reagents required for the hydrometallurgical plant include:

- Sulphuric acid;
- Ammonium or sodium bicarbonate;
- Quick lime slaked to hydrated lime;
- Limestone;
- Magnesium oxide; and
- Sodium hydroxide (caustic soda).

The process water generated from the hydrometallurgical plant cannot be reused in the plant due to reagent solutes (i.e. sodium), and as such disposal of this water (~470,000 to 480,000 m^3/annum) to an evaporation pond will be required.

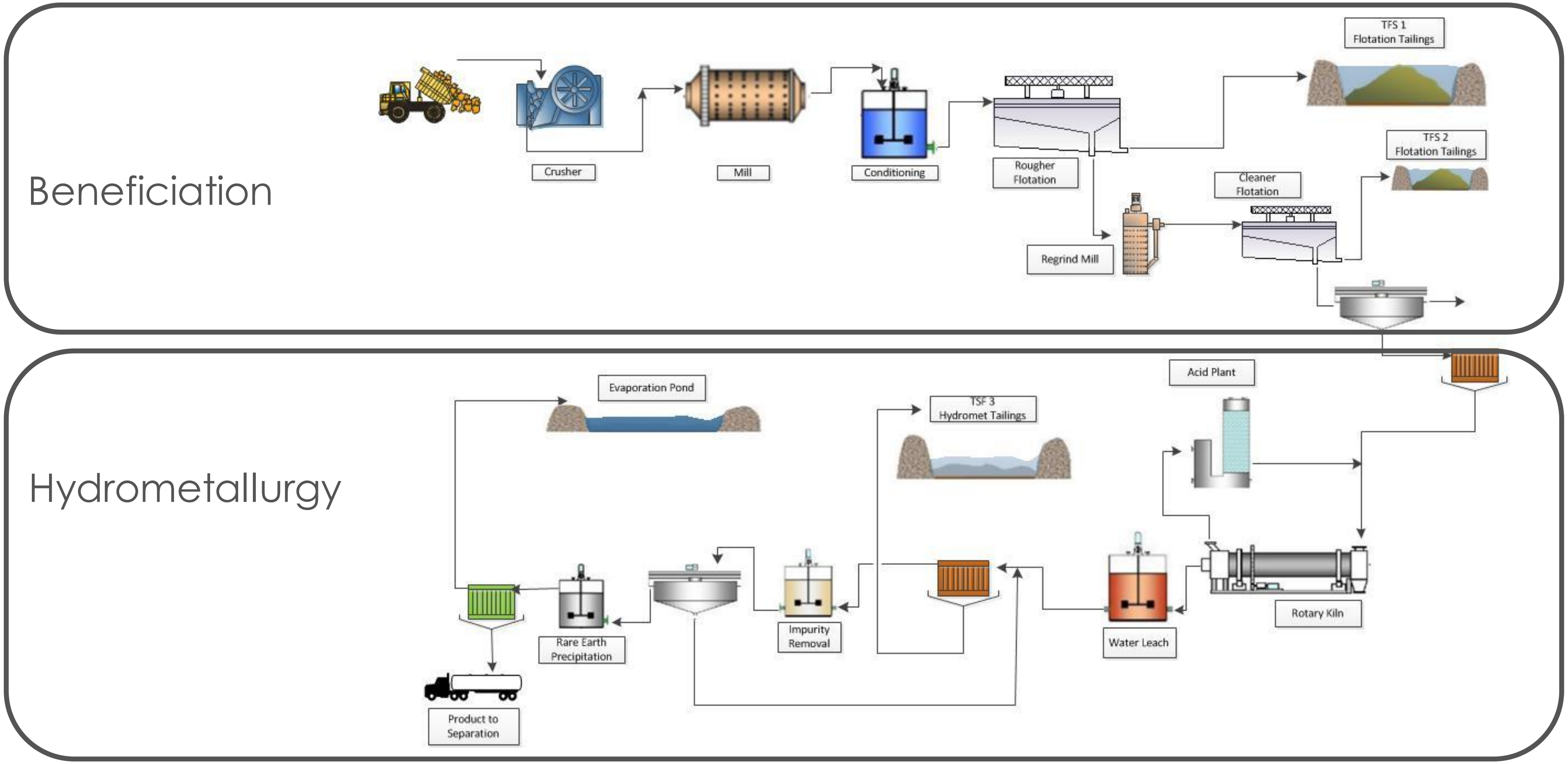


Figure 3 Process flowsheet

3.3.3.3 Tailings disposal and storage

The three separate processing tailings streams will be disposed in distinct TSFs. **Table 4** summarises chemical and physical characteristics, source and disposal location of each tailings stream. **Table 5** summarises the TSF design features.

Table 4 Source, disposal and general characteristics of tailings streams

Processing source	Tailings mass (%)	Annual rate (tpa)	Physical processing	Chemical properties	Radionuclide concentration	Disposal
Beneficiation	95.0%					
1. Rougher circuit	91.0%	932,100	Crushed and milled ore, flotation	Trace flotation reagents; pH 10-11.5	<1 Bq/g (head of chain)	TSF 1
2. Cleaner circuit	4.0%	37,200	Crushed and milled ore, flotation	Trace flotation reagents; pH 10-11.5	~ 7 Bq/g (head of chain)	TSF 2
Hydrometallurgical	5.0%	56,000	Acid Heating Water leach Neutralisation and waste removal Thickening	Trace sulphuric acid; U and Th; Iron phosphates Aluminium; Gypsum Metal hydroxides; pH 7-8	~24 Bq/g (head of chain)	TSF 3
TOTAL	**100%**	**1,025,300**				

Table 5 Summary of proposed TSF design features

Design feature	TSF1	TSF2	TSF3
Proportion of tailings	91%	4%	5%
Maximum height (m)	6 metre perimeter embankments; Tailings stack 15 metres	6 metre perimeter embankments	6 metre perimeter embankments
Area (Ha)	100 Ha	7 Ha	11 Ha
Number of cells	1	1	1
Construction	Downstream perimeter embankment raising	Downstream perimeter embankment raising	Downstream perimeter embankment raising
Discharge method	Single point Central Thickened Discharge (CTD)	Perimeter spigots	Perimeter spigots
Lining	Proof compacted basal clayey sand layer	HDPE / other and compacted clayey sand	HDPE / other and compacted clayey sand
Encapsulation	Nominal capillary break / erosion protection; growth medium (soil and rock armour)	HDPE / compacted clayey sand base; HDPE / Compacted Clay Liner (CCL) engineered capping with growth medium (soil and rock armour). Design in accordance with IAEA safety standards to provide safe containment of NORM for periods beyond the extent of institutional control	HDPE / compacted clayey sand base; HDPE / CCL engineered capping with growth medium (soil and rock armour). Design in accordance with IAEA safety standards to provide safe containment of NORM for periods beyond the extent of institutional control
Leak detection	Downstream groundwater monitoring bores	Downstream groundwater monitoring bores	Downstream groundwater monitoring bores; Underdrain detection between compacted clay and HDPE liners with sump

3.3.4 Support infrastructure

3.3.4.1 Power supply

Anticipated annual power requirement across mining, processing and support infrastructure will be 12 Megawatt (MW). Power requirements to the processing plant and associated infrastructure are anticipated to be in the order of 10 MW per annum, predominantly supplied through a combination of solar energy and diesel generator sets. Power supply for the accommodation facilities will be supplied by diesel generator sets located adjacent to the accommodation facilities.

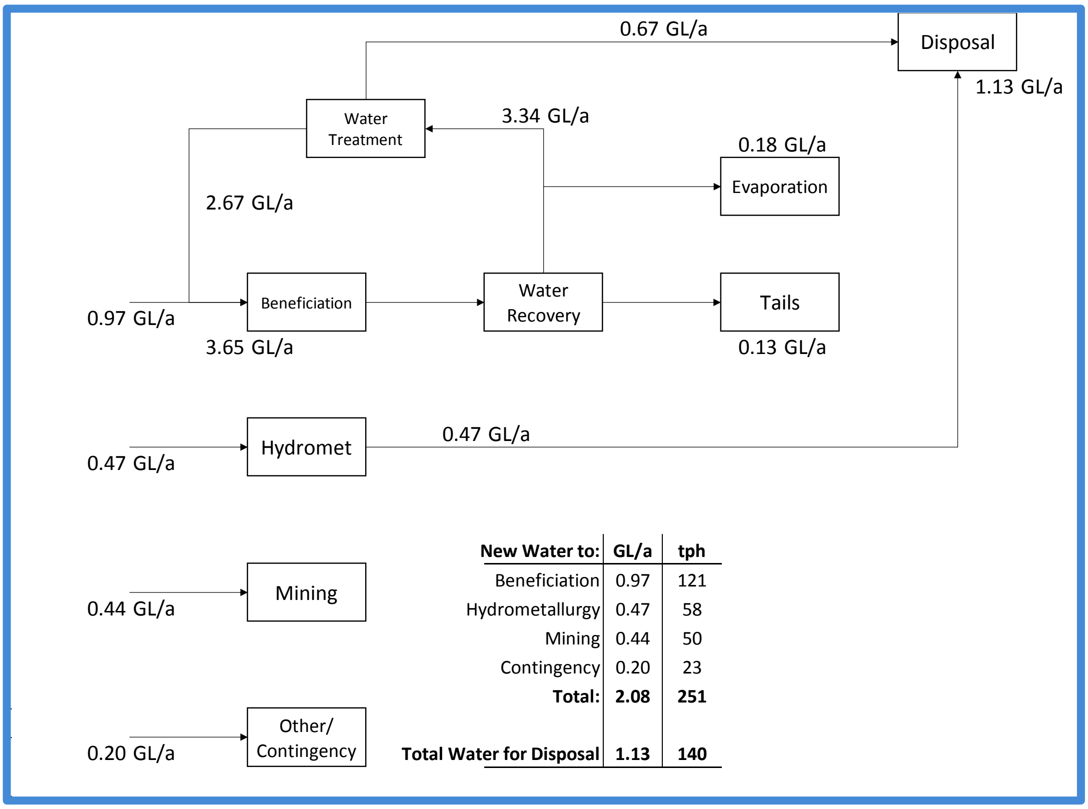
3.3.4.2 Water supply

An estimated annual water demand for the Proposal of up to 2.5 gigalitres (GL) per year (79.3 L/sec), the majority of which will be supplied by groundwater.

WATER BALANCE

The majority of the water demand will come from ore processing, with minor volumes required for dust suppression, fire protection, equipment wash down and potable uses across the Proposal. Water reuse will primarily occur within the processing plant (TSF1 and TSF2 decant water). The Proposal's water balance is provided in **Figure 4**.

Of the water for processing, the beneficiation component of the project comparatively requires the most water, and thus water recovery and recycle is incorporated into the design to improve the efficiency of project water requirements (i.e. approx. 70% of beneficiation water is recycled representing approx. 55% of total water demand). All water required by the hydrometallurgical component of the process will need to be disposed of, and therefore does not contribute to the recycled water system that reduces project water demand. Water disposal will occur in an evaporation pond and TSFs.



New Water to:	GL/a	tph
Beneficiation	0.97	121
Hydrometallurgy	0.47	58
Mining	0.44	50
Contingency	0.20	23
Total:	**2.08**	**251**
Total Water for Disposal	**1.13**	**140**

Figure 4 Water balance

WATER SOURCE

Groundwater will be abstracted via groundwater production bores over an ironstone strike extending 12 km, and where possible from in-pit sumps, into transfer dams prior to being distributed to different storage locations around the Proposal for use in ore processing, dust suppression and potable water uses. A dedicated bore will provide water for the accommodation village. Raw water will undergo necessary water treatment through a Reverse Osmosis (RO) plant to meet potable water quality parameters.

Pit dewatering, including the two existing production bores, is expected to satisfy approximately 20% of this demand in the initial stage of the project, increasing to 90% towards the end of the mine life. The remainder of the demand is expected to be met by a network of water supply bores located along the ironstone aquifer away from the pit areas:

- Yangibana, which could provide a water source prior to the commencement of mining at this deposit (i.e. until Year 4).
- Auer North is located approximately 5 km west of Fraser's and anecdotally reported groundwater inflows similar to Bald Hills, i.e. 6 to 8 L/sec per bore.
- The Western Belt, comprising approximately 12 km of ironstone strike length extending east from Yangibana, suggests aquifer properties along the ironstone are consistent with those reported in Fraser's, Bald Hills and Yangibana. Potential water yields will be in the order of 6 to 8 L/sec per bore.

It is expected that the project water demand will be sourced from these three areas and pit dewatering activities (as shown in **Table 6**).

Table 6 Water supply

Mining Year	Confirmed Yield (L/sec)		Estimated Yield (L/sec)			Total Potential Yield (L/sec)
	Pit Dewatering	Water Supply Bores	Yangibana (1 - 2 bores)	Auer North (1 - 2 bores)	Western Belt (up to 10 bores)	
Year 1	-	14	6-12	6-12	Up to 60	>79.3
Year 2	-	14	6-12	6-12	Up to 60	>79.3
Year 3	1	14	6-12	6-12	Up to 60	>79.3
Year 4	21	11	-	6-12	Up to 60	>79.3
Year 5	<u>31.5*</u>	-	-	6-12	Up to 60	>79.3
Year 6	<u>49</u>	-	-	6-12	Up to 60	>79.3
Year 7	<u>75</u>	-	-	6-12	Up to 60	>79.3

* The figures underlined include continued sump pumping from Fraser's and Bald Hills, after mining of these two pits cease.

3.3.4.3 Transport Corridor and Port Facility

Access to the mine site will be via the Cobra-Gifford Creek Road. Works to upgrade some sections of Shire of Upper Gascoyne roads (Cobra - Dairy Creek Road) will be required to establish a safe and reliable route for transport of reagents, fuel and other consumables to site, and transport of the product to port for export. Borrow pits, laydown areas and a water supply will be required for road works during the construction stage and for ongoing road maintenance.

The product will be packaged at the mine site prior to road transport via existing roads to a port facility (i.e. Geraldton is the preferred port option). Existing facilities at the port will be used for the storage of packaged products. Transport from the port will occur on container ships via existing ship loading facilities and shipping lanes.

3.3.4.4 Other infrastructure

An aerodrome and accommodation facilities will be located approximately 10 km south-southwest of the processing plant. In accordance with Civil Aviation Safety Authority's *Manual of Standards Part 139 - Aerodromes*, the aerodrome will have a Code 3C runway, 30 m wide and 1,800 m long (Commonwealth of Australia 2012). The accommodation facilities will allow for an estimated peak workforce of up to 200 people during construction, and 180 people during operations. Single storey accommodation blocks are proposed, with laundry, mess and recreational facilities.

Additional infrastructure includes administration facilities, workshops, parking areas, a landfill for putrescible and industrial waste, contaminated waste facility, wash down bay, bioremediation area, sewage treatment plant, water transfer infrastructure, communications facilities, power infrastructure, surface water drainage infrastructure, bulk diesel tank farm and an explosives magazine.

3.4 Timing and Staging

The Proposal will have a life of mine of approximately seven years, however this may be extended subject to outcomes of on-going mineral exploration and economic conditions. This Proposal represents Stage 1 of the Yangibana Rare Earths Project. Future mining areas may represent Stage 2 and would be subject to future Approvals considerations.

Construction is currently planned to commence in the first quarter (Q1) of 2018. Commissioning is planned for Q4, 2019.

3.5 Local and Regional Context

The proposal is located 10 km north of the Lyons River, approximately 150 km northeast of Gascoyne Junction and approximately 150 km southeast of the mining hub of Paraburdoo (Figure 1).

There are no other mining developments in the local Shire of Upper Gascoyne. While potential mineral deposits are known to occur in the Gascoyne Region, the only mining operations underway are salt production at Useless Loop in the Shire of Shark Bay and at Lake MacLeod near Cape Cuvier, north of Carnarvon.

Mount Augustus National Park is approximately 80km south east of the Proposal and the north eastern corner of the Kennedy Range National Park is approximately 100km south west of the Proposal.

4 STAKEHOLDER ENGAGEMENT

4.1 KEY STAKEHOLDERS

Key stakeholders for the proposal include:

1. Commonwealth government:
   - Department of the Environment and Energy (DoEE)
2. State Government:
   - Department of Mines and Petroleum (DMP)
   - Radiological Council
   - Department of Environment Regulation (DER)
   - Department of Water (DoW)
3. Local Government:
   - Shire of Upper Gascoyne
4. Native Title claimants
   - combined Thin-Mah Warianga, Tharrikari, Jiwarli native title claimants (WC2016/003; WAD464/2016), represented by the Yamatji Marlpa Aboriginal Corporation (YMAC)
5. Pastoralist
   - Bagden Pty Limited, Wanna and Gifford Creek Stations

The DMP are the assigned lead agency for this proposal and provide on-going Approvals advice in relation to government processes and play a role in ensuring issues associated with government Approvals are resolved.

4.2 STAKEHOLDER ENGAGEMENT PROCESS

Hastings has implemented an external and community relations strategy over the past year, and developed the methodology for ongoing social assessment, engagement, community investment and community consultation.

A Stakeholder Engagement Management Plan has been developed to provide a framework for Hastings to engage in structured, meaningful and effective stakeholder engagement and management. The framework comprises a series of work plans, which together form the company's comprehensive external relations plan for the period 2016 to 2021, including key milestones such as feasibility study completion, Proposal financial investment decision, construction, commissioning, and first shipment.

Hastings is committed to ongoing stakeholder communication, engagement and consultation through the planning and approval phase, and through the construction and operational phases of the Project. The Stakeholder Engagement Management Plan strives to provide access to government, to facilitate community partnering, to enable access to land, and a myriad of other objectives to develop and protect the company's reputation.

Hastings can demonstrate, through research and community consultation, that the company has developed and maintains strong relations with the shires and local communities and, utilising an external relations program, that these relationships will continue to be enhanced for the mutual benefit of the Project and relevant stakeholders.

Hastings has adopted principles from the Ministerial Council on Mineral and Petroleum Resources (MCMPR) *Principles for engagement with communities and stakeholders* (2005):

- Communication: Open and effective engagement involves both listening and talking:
  - Two-way communication
  - Clear, accurate and relevant information
  - Timeliness
- Transparency: Clear and agreed information and feedback processes:
  - Transparency
  - Reporting
- Collaboration: Working cooperatively to seek mutually beneficial outcomes.
- Inclusiveness: Recognise, understand and involve communities and stakeholders early and throughout the process.
- Integrity: Conduct engagement in a manner that fosters mutual respect and trust.

4.3 STAKEHOLDER CONSULTATION

On-going proactive stakeholder consultation has been underway since 2015 (**Table 7**).

Table 7 Stakeholder consultation

Stakeholder	Date	Issues/topics raised	Proponent response/outcome
Commonwealth government			
Dept of Industry, Innovation and Science	6 October 2016	Roundtable discussion of rare earths and lithium mining in Australia	Provision of information.
DoEE	1 December 2016	Pre-referral meeting. Draft referral provided prior to the meeting. DoEE raised specific aspects that required additional information and referral process, timelines, fees.	Referral documentation revised based on DoEE advice.
State government			
DMP	4 February 2015	Briefing on the Proposal	
DMP	11 March 2015	Project update and DER advice	
DMP	1 December 2015	Briefing on Proposal, outline of potential environmental	

Stakeholder	Date	Issues/topics raised	Proponent response/outcome
		impacts. Seeking advice from DMP	
DMP and DSD	20 October 2016	Overview of current status of the Proposal, schedule, environmental studies and comparison with Browns Range EIA. Advice received from DMP regarding water balance and source, surface water mitigation, heritage sites, TSF design, and WRL to sit outside of pit zone of instability. DMP, as lead agency, to be the first point of contact.	Hastings will ensure these requirements are addressed in the Mining Proposal. A water source will be developed for the state Referral to the EPA.
DMP	26 October 2016	DMP was invited to attend environmental risk assessment workshops (held as a series of workshops). DMP declined to attend due to schedule conflicts but would provide feedback on the risk assessment.	Risk assessment to be provided to DMP for review.
DMP, Resources Safety	30 October 2016	Outcomes of radionuclide studies and monitoring to-date. DMP raised the following considerations: Cross-reference TSF designs with landfill specifications, combination of clay liner and membrane liner to ensure leaching of TSF doesn't occur, capping and drainage system, use of analogue sites in closure planning, keen to see holistic approach to waste characterisation with heavy metal assessment as well as radionuclide assessment, on-going waste characterisation with commitment to update RWMP annually, and note that rare earths have	Advice from DMP noted and provided to TSF design consultants. Focus on gamma baseline studies as the more intense form of radiation. Gamma baseline studies and monitoring has been undertaken which will inform closure planning. Radionuclides considered within the waste characterisation report to provide holistic approach.

Stakeholder	Date	Issues/topics raised	Proponent response/outcome
		radionuclides that mainly emit Beta radiation.	
DMP, Resources Safety	25 January 2017	Change of DMP staff, briefing on proposal and aspects relating to radiation.	Preliminary advice received.
Radiological Council*	4 February 2015	Briefing on proposal.	Preliminary advice received.
DAA	9 May 2016	Advice sought on the selection of heritage survey participants.	Advice received, (noting that there was no native title claim over the area at the time).
DAA	23 January 2017	Overview of the proposal and summary of heritage survey work undertaken to date.	Advice from DAA on s18 approval process.
DER	17 March 2015	Briefing on proposal, preliminary advice received.	
DER	14 December 2016	Briefing on proposal.	Next meeting to be held for scoping of Part V approvals at the end of the EIA process.
DoW	6 October 2016	Overview of the proposal. Briefing on water requirements for the proposal. Advice received: Consider doing isotope analysis to further understand age of water source and potential for recharge; likely that more but brackish water exists closer to the Lyons River. Better quality water is likely available with distance from the River but at lower volumes; and TSF location appeared such that water would not flow into creeks	Isotopic analysis is underway. DoW advice communicated to consultants.

Stakeholder	Date	Issues/topics raised	Proponent response/outcome
		or rivers except after heavy rainfall events.	
DoW	13 October 2016	Requirement for 5C licence for test pumping to determine drawdown contours in each pit.	Project description and test pumping details provided to DoW, Geraldton. No 5C licence required.
DPaW	2 April 2015	Preliminary advice on flora & fauna survey requirements and design from DPaW.	
DPaW	30 September 2016	Overview of environmental survey outcomes, subterranean fauna assessments and on-going studies, consultation requirements with DPaW.	No further consultation required unless EPA formally request DPaW input. No subterranean fauna expertise in DPaW, so they would request input from WA Museum if required.
OEPA	10 September 2015	Overview of Proposal, presentation of available environmental data particularly flora and fauna, hydrology and radiation assessments.	
OEPA	10 March 2016	Briefing on Proposal, outline of potential environmental impacts.	
OEPA	12 October 2016	Concern raised about whether or not referral of the Proposal could be given a level of assessment during the governments 'caretaker phase'. The OEPA officer seemed to think this was likely and recommended a pre-referral meeting ASAP.	Pre-referral meeting with OEPA was then scheduled for 19 October 2016. Plans to refer in mid-November.
OEPA	19 October 2016	Pre-referral meeting. Briefing on proposal, API level impact assessment requirements and timing of	Delay of referral in order to ensure all necessary studies have been completed.

Stakeholder	Date	Issues/topics raised	Proponent response/outcome
		referral during caretaker phase. OEPA officers advised that the EPA could provide proponents with a level of assessment during caretaker phase. Key requirements: all studies to be completed with no information gaps, adequate stakeholder consultation with low community interest, high quality documentation.	
OEPA	23 January 2017	Preliminary feedback re referral information included: inclusion of port and transport corridor in proposal, water drawdown impacts to GDE to be determined, height of waste rock landforms, risks associated with flora along access road, minor revisions to form and ERD	Address OEPA feedback in final referral form and ERD.
CASA	31 October 2016	Registration requirements and details for notification of an airstrip. CASA then provided a brief overview of their requirements highlighting the importance of have the correct consultants do the design and ensuring it is constructed to design specifications. No environmental issues were raised.	Noted. A formal letter was then sent showing the location of the airstrip, runway code and timeframes for construction.
AirServices Australia	7 November 2016	Location and overview of airstrip design intent was provided in a letter. AirServices noted that the airstrip was in a good location from a safety perspective. No environmental issues were raised.	Noted.

Stakeholder	Date	Issues/topics raised	Proponent response/outcome
Local Government			
Shire of Upper Gascoyne	26 May 2016	Project overview and update on project status. Discussed access road options. The Shire provided information on council maintenance operations of the Dairy-Creek Road and requirements during project operations. Briefing on status of engineering and option study for access road.	Shire provided MRWA road assessment information.
Shire of Upper Gascoyne	25 October 2016	Logistics for community forum and advertising. The Shire noted that the Gassy News was the best form of advertising in remote areas, pastoralists and everyone in town will be informed. Advertisement will be distributed as per the Gassy News to pastoralists as well as those in town. Briefing on status of engineering and option study for access road	Advertisement prepared and distributed.
Shire of Upper Gascoyne	30 November 2016	Briefing on the Proposal, non-committal until they know that Project will go ahead. Interest in future maintenance requirements to maintain good road condition with additional vehicle movements to and from the proposal.	Hastings to keep the Shire updated of progress
Gascoyne Development Commission (GDC)	30 November 2016	Overview of Proposal, approvals status and requirements, environmental aspects. GDC discussed development initiatives in the Gascoyne region.	Hasting to keep GDC updated of progress and provide a copy of the presentation.

Stakeholder	Date	Issues/topics raised	Proponent response/outcome
Traditional Owners			
Traditional owners field visits	2-4 August 2016 and 21 September 2016	Location of proposed mine areas, processing plant and associated infrastructure visited by TOs. TO's highlighted importance of story line associated with the Lyons River and its tributaries. Concerns raised to protect the River.	Refer to Appendix 8.2 report. Hastings has put a 150m exclusion buffer on either side of the Lyons river, Fraser Creek and Gifford Creek. Hastings has been able to avoid significant heritage sites identified to-date.
YMAC	9 May 2016	Advice sought on the selection of heritage survey participants	Advice received, (noting that there was no native title claim over the area at the time)
YMAC	1 December 2016	Introductory meeting and outline of likely future tenure requirements and engagement.	YMAC to seek instructions from the combined Thin-Mah Warianga, Tharrikari, Jiwarli native title claimants
Pastoralists			
Wanna station	2014 – to-date	Updates of exploration activities and feasibility studies conducted on Wanna station. Land access and logistics arrangements in consultation with Wanna station.	
Wanna Station	28 May, 2016	Site visit with station manager to look at infrastructure locations on the station via car and flying over the site in small aircraft. Gain understanding of pastoral activities and how to integrate with infrastructure planning.	Provision of infrastructure design plan as developed.

Stakeholder	Date	Issues/topics raised	Proponent response/outcome
Wanna Station	5 October, 2016	Proposal overview. Concerns raised about infrastructure locations and ensuring water in pastoral bores does not become contaminated.	Advised that seepage of contaminants is regulated by several levels and departments of government including DoEE, EPA, DMP (environment and resources safety), Radiological Council and DER. Field visit with station manager is planned to go over latest infrastructure plans. Baseline water quality sampling of nearest pastoral bores to the Project.
Wanna Station	26 October, 2016	Review infrastructure planning and location to address pastoral leaseholder concerns. High value pastoral country at the location where the airstrip and roads is proposed.	Revise location of the air strip and access road. On-going consultation with Wanna required.
Wanna Station	4 November, 2016	Project update. Request for revised infrastructure map with revised aerodrome and road locations.	Map provided.
Edmund Station	15 November, 2016	Request via phone and email to meet so that Hastings can provide a Project update. No response received.	
Wanna Station	1 December, 2016	Discuss land tenure and an access agreement.	Draft access agreement prepared by Hastings.
Edmund Station	6 January, 2016	Request via email to meet so that Hastings can provide a Project update. Environmental Fact Sheet attached to email.	

Stakeholder	Date	Issues/topics raised	Proponent response/outcome
Community			
Gascoyne Junction	30 November 2016	Community forum held at community resource centre in Gascoyne Junction. Environmental fact sheet summarising environmental issues, proposal overview and invite to provide comment.	Despite advertising the event, the only two attendees raised no issues. The community resource centre will ensure residents are sent a copy of the environmental fact sheet and will maintain copies on display at the centre.
Conservation Council	19 October 2016	Letter sent informing of the proposal and invite to meet if further information is required.	No response received.
Wilderness Society	19 October 2016	Letter sent informing of the proposal and invite to meet if further information is required.	No response received.

* Despite on-going email and phone messages to provide a project update, Hastings have not received a response from the Radiological Council in 2016.

5 Environmental principles and factors

This section was guided by the EPA (2016r) *Statement of Environmental Principles, Factors and Objectives* as the basis for the environmental impact assessment.

5.1 Principles

Section 4A of the *Environmental Protection Act 1986* (WA; EP Act) describes the principles of environmentally sustainable development. These principles are considered in the context of the Proposal (**Table 8**).

Table 8 EP Act Principles

Principle	Consideration
1. The precautionary principle *Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation.* *In the application of the precautionary principle, decisions should be guided by:* *a) careful evaluation to avoid, where practicable, serious or irreversible damage to the environment; and* b) *an assessment of the risk-weighted consequences of various options.*	Hastings recognises the importance of minimising environmental impacts to ensure the company's longevity, success, growth and positioning in domestic and global markets. This will be achieved by successful mitigation of potential risks to the environment. An overarching Environmental Management System (EMS) will be implemented to ensure risks associated with all proposed activities with the potential to impact the environment are mitigated to as low as reasonably practicable (ALARP). Consideration of risk has involved completing comprehensive biological and physical baseline surveys and assessments to identify key environmental factors. Risk of impact to key environmental factors as a result of implementing the Project has then been considered. Where there are information gaps or a lack of scientific certainty, a conservative approach has been taken to assess risk. Careful evaluation has been made of options to avoid, or minimise any potential impacts to the environment. The Proposal will use best practice design and management to reduce risk, where practicable. The Proposal has then considered management and rehabilitation of potential impacts to key environmental factors.
2. The principle of intergenerational equity *The present generation should ensure that the health, diversity and productivity of the environment is maintained and enhanced for the benefit of future generations.*	The Proposal presents the Western Australian economy with the opportunity to diversify its mineral exports, thus providing a more resilient employment environment. The rare earths concentrate is used to create products, namely magnets that are utilised in the renewable energy markets i.e. wind turbines, hybrid cars. This contributes to health, diversity and productivity of the global environment by reducing

Principle	Consideration
	our dependence on fossil fuels, thus creating a more sustainable environment for future generations. The biological surveys conducted to-date have broadened our knowledge of the local environment, ensuring that we can mitigate potential risks and thus maintain the health, diversity and productivity of the local environment.
3. Principles relating to improved valuation, pricing and incentive mechanisms *(1) Environmental factors should be included in the valuation of assets and services.* *(2) The polluter pays principles – those who generate pollution and waste should bear the cost of containment, avoidance and abatement.* *(3) The users of goods and services should pay prices based on the full life-cycle costs of providing goods and services, including the use of natural resources and assets and the ultimate disposal of any waste.* *(4) Environmental goals, having been established, should be pursued in the most cost effective way, by establishing incentive structure, including market mechanisms, which enable those best placed to maximise benefits and/or minimise costs to develop their own solution and responses to environmental problems.*	The Proposal will be subject to a Preliminary Mine Closure Plan prepared in accordance with the *Guidelines for Preparing Preliminary Mine Closure Plans* (DMP and EPA, 2015). The Mine Closure Plan will be a dynamic document, which having identified post-mining land use objectives, consulting with key stakeholders and conducting on-going studies or research to fill information gaps, will be reviewed and updated. Addressing closure objectives throughout all phases will ensure a cost-effective way to reduce liabilities and risks associated with mine closure. A Radiation Waste Management Plan, prepared in accordance with the *NORM guideline 4.2* (DMP, 2010), and a Tailings Storage Facilities Operations Manuals, prepared in accordance with *Guidelines on the Development of an Operating Manual for Tailings Storage* (DMP, 1998) will ensure that tailings are contained and encapsulated to the highest standards and guidelines.
4. The principle of the conservation of biological diversity and ecological integrity *Conservation of biological diversity and ecological integrity should be a fundamental consideration.*	Conservation of biological diversity and ecological integrity is fundamental to Hastings approach to environmental management and is a major environmental consideration for the Proposal. Biological assessments have been conducted over an extensive study area to identify conservation significant species and ecosystems in order to avoid and/or minimise disturbance of these areas. The Proposal has been designed to minimise potential impacts to preliminary key environmental factors.

Principle	Consideration
5. The principle of waste minimisation *All reasonable and practicable measures should be taken to minimise the generation of waste and its discharge into the environment.*	Waste management of the Proposal involves minimising generation of wastes through: • Avoid and reduce at source • Reuse and recycle, including salvage • Treat and/or dispose. In doing so, mine planning aims to minimise strip ratios to reduce the amount of mine waste rock. The majority of the power supply for the processing plant and support infrastructure will be derived from solar energy. Water from the processing plant will be recycled and reused, where possible. Contractor management (i.e. contracts, audits, coordination of waste segregation and disposal) will ensure waste is recycled, where possible.

5.2 Key environmental factor 1: Flora and vegetation

5.2.1 EPA objective

To protect flora and vegetation so that biological diversity and ecological integrity are maintained.

4.2.2 Policy and guidance

Laws and regulations relevant to the consideration of flora and vegetation include:

Agricultural and Related Resources Protection Act 1976 (WA)

Biosecurity and Agriculture Management Act 2007 (WA)

Bush Fires Act 1954 (WA)

Environment Protection and Biodiversity Conservation Act 1999 (Commonwealth)

Environmental Protection Act 1986 (WA)

Wildlife Conservation Act 1950 (WA)

Relevant guidelines include:

EPA (2000) Position Statement No. 2: Protection of native vegetation in Western Australia;

EPA (2002) Position Statement No. 3: Terrestrial biological surveys as an element of biodiversity protection;

EPA (2003) Guidance Statement 55: Implementing best practice in proposals submitted to the environment impact assessment process;

EPA (2004) Guidance Statement No. 51: Terrestrial flora and vegetation surveys for environmental impact assessments in Western Australia;

EPA (2016n) Technical Guidance - Flora and vegetation surveys for environmental impact assessment; and

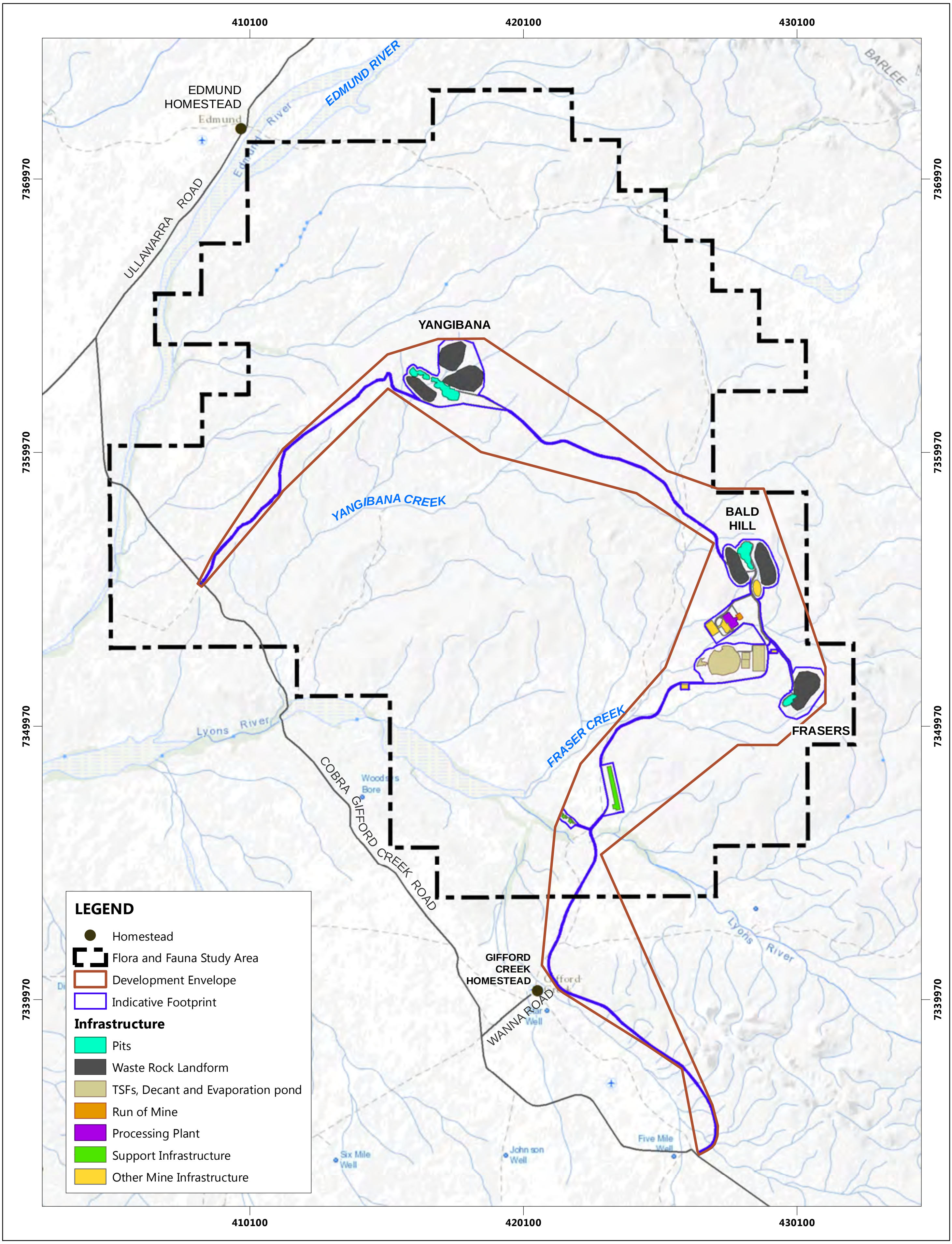
EPA (2016e) Environmental Factor Guideline: Flora and vegetation.

5.2.2 Receiving environment

The following studies have informed this section:

- Flora and Vegetation Report (Ecoscape 2015; Appendix 1-1)
- Flora and Fauna Memo (Ecoscape 2017; Appendix 1-2)
- GDE Memo (Ecoscape 2017; Appendix 1-3)
- Environmental Risk for Ionising Contaminants Assessment (ERICA; in JRHC Enterprises 2016; Appendix 5-6)

The historical land use has been pastoral, and evidence of degradation along drainage lines occurs where hooved mammals and weeds are present. Other minor areas are classified as degraded from pastoral activities and exploration tracks and pads (to be rehabilitated at completion of exploration programme). Despite this, the majority (~71%) of the survey area (**Figure 5**) is in Excellent condition with native vegetation largely intact (Ecoscape 2015; Appendix 1-1).



SCALE: 1:180,000 @ A4

COORDINATE SYSTEM: GDA 1994 MGA ZONE 50
PROJECTION: TRANSVERSE MERCATOR
DATUM: GDA 1994
UNITS: METER

DATA SOURCES:
TOPOGRAPHIC LAYERS: GEOSCIENCE AUSTRALIA
SERVICE LAYERS: GEOSCIENCE AUSTRALIA

ecoscape

PROJECT NO: 3402-15

REV	AUTHOR	APPROVED	DATE
0	JN	ERR	17/01/2017

N

0 1 2 3 4 5 km

FLORA AND FAUNA STUDY AREA AND DEVELOPMENT ENVELOPE

YANGIBANA RARE EARTHS PROJECT

CLIENT: HASTINGS

FIGURE 05

FLORA

A total of 472 vascular flora taxa were recorded in the survey area (55,000 Ha; **Figure 5**). No threatened flora listed under the EPBC Act (Cwth) and *Wildlife Conservation Act 1950* (WC Act; WA) were recorded in the study area. Eight priority flora (Department of Parks and Wildlife (DPaW) listed) were recorded in the study area:

- *Acacia curryana* (Priority 1 (P1));
- *Rhodanthe frenchii* (P2);
- *Solanum octonum* (P2);
- *Wurmbea fluviatilis* (P2);
- *Gymnanthera cunninghamii* (P3);
- *Sporobolus blakei* (P3);
- *Goodenia berringbinensis* (P4); and
- *Goodenia nuda* (P4).

58 taxa were recorded as having significant range extensions or filling substantial range gaps in species distribution. Additionally, one undescribed species (*Elacholoma sp.* 'Showy Flowers') was recorded in the survey area but outside the Proposal development envelope.

VEGETATION

The tenement area is located within the Gascoyne IBRA region that consists of three major subregions: Ashburton, Augustus and Carnegie (Thackway & Cresswell 1995 in Ecoscape 2015; Appendix 1). The development envelope occurs in the Augustus subregion, described in the 2002 Biodiversity Audit of Western Australia's 53 Biogeographical Subregions (Desmond et al. 2001 in Ecoscape 2015) as:

> *Rugged low Proterozoic sedimentary and granite ranges divided by broad flat valleys. Also includes the Narryera Complex and Bryah Basin of the Proterozoic Capricorn Orogen (on northern margin of the Yilgarn Craton), as well as the Archaean Marymia and Sylvania Inliers. Although the Gascoyne River System provides the main drainage of this subregion, it is also the headwaters of the Ashburton and Fortescue Rivers. There are extensive areas of alluvial valley-fill deposits. Mulga woodland with Triodia occur on shallow stony loams on rises, while the shallow earthy loams over hardpan on the plains are covered by Mulga parkland. A desert climate with bimodal rainfall. The subregional area is 10,687,739 Ha.*

Ten land systems occur within the surveyed tenement areas. All of these land systems are well represented beyond the development envelope. The James System occupies the greatest area, i.e. 31.2% of the tenement areas, which represents 8.24% of its total extent in the Gascoyne bioregion, followed by the Phillips System occupying 21.7% of the tenement areas, which represents 1.43% of its total extent.

Four pre-European vegetation associations occur within the tenement areas:

- 18 Low woodland; mulga (*Acacia aneura*)
- 165 Low woodland; mulga and snakewood (*Acacia eremmaea*)
- 166 Low woodland; mulga and *Acacia victoriae*
- 181 Shrublands; mulga and snakewood scrub

4.42% of vegetation association 165 occurs within the tenement areas, with 100% of its pre-European extent remaining in the Gascoyne bioregion. Less than 1% of the total extent of the other three vegetation associations occur within the tenement areas.

Twenty vegetation types were recorded from the tenement areas, with the following ten vegetation types found within the development envelope:

1. **AaEpDr:** *Acacia aptaneura* low open woodland over *Eremophila phyllopoda subsp. obliqua, Acacia tetragonophylla* and *Dodonaea petiolaris* mid open shrubland over *Dysphania rhadinostachya, Bulbostylis barbarta* and *Gomphrena cunninghamii* low open forbland/sedgeland
2. **AcEt:** *Acacia cyperophylla* var. *cyperophylla* low open woodland over *Eragrostis tenellula*, *Eragrostis cumingii* and *Eriachne aristidea* low tussock grassland
3. **ApSgAc:** *Acacia pruinocarpa* and *Grevillea berryana* low open woodland over *Senna glutinosa* subsp. x *luerssenii* and *Eremophila phyllopoda* subsp. *obliqua* mid sparse shrubland over *Aristida contorta* and *Eriachne pulchella* subsp. *dominii* low grassland
4. **ArPc:** *Acacia ramulosa* var. *linophylla, A. aptaneura* and *A. pruinocarpa* low woodland over *Paspalidium clementii* and *Dysphania rhadinostachya* low grassland/forbland
5. **AtGc:** *Acacia tetragonophylla, Dodonaea petiolaris* and *Eremophila latrobei* subsp. *latrobei* mid open shrubland over *Gomphrena cunninghamii*, *Aristida contorta* and *Cymbopogon ambiguus* low open forbland/grassland
6. **AxEcAc** *Acacia xiphophylla*, *A. synchronicia* and *A. macraneura* low open woodland over *Eremophila cuneifolia, Senna artemisioides* subsp. *oligophylla, S. glutinosa* subsp. x *luerssenii* mid open shrubland over *Aristida contorta* and *Enneapogon caerulescens* low sparse tussock grassland
7. **EeAc:** *Eremophila exilifolia*, *Acacia tetragonophylla* and *A. kempeana* mid open shrubland over *Aristida contorta* and *Eriachne pulchella* subsp. *dominii* low sparse tussock grassland
8. **EpAc:** *Eremophila phyllopoda* subsp. *obliqua, Acacia tetragonophylla* and *Senna artemisioides* subsp. *helmsii* mid open shrubland over *Aristida contorta*, *Eriachne pulchella* subsp. *dominii* and *Portulaca oleracea* low grassland/forbland
9. **EvCc:** *Eucalyptus victrix* and *Acacia citrinoviridis* mid open forest over **Cenchrus ciliaris* and **C. setiger* mid tussock grassland
10. **Mp:** *Maireana polypterygia*, *Lawrencia densiflora* and *Eremophea spinosa* low open chenopod shrubland/forbland

One vegetation type (EcMgCc) represents a Groundwater Dependent Ecosystem (GDE) being characterised by *Eucalyptus camaldulensis*. Vegetation types, EvCc, EvReMg, AcEt and AcAsCc, may represent GDEs due to the presence of *Eucalyptus victrix*.

No Threatened Ecological Communities (TEC) or Priority Ecological Communities (PEC), characterised by a vegetation type, were recorded within the study area, and none are listed for the Gascoyne bioregion.

INTRODUCED SPECIES

Twenty-four introduced plant species exist in the study area:

- *Acetosa vesicaria* (Ruby Dock)
- *Argemone ochroleuca* (Mexican Poppy)
- *Asphodelus fistulosus* (Onion Weed)

- *Bidens subalternans* var. *simulans*
- *Cenchrus ciliaris* (Buffel Grass)
- *Cenchrus setiger* (Birdwood Grass)
- *Chenopodium murale* (Nettle-leaf Goosefoot)
- *Citrullus lanatus* (Pie Melon)
- *Cucumis myriocarpus* (Prickly Paddy Melon)
- *Cuscuta planiflora*
- *Cynodon dactylon* (Couch)
- *Datura leichhardtii* (Native Thornapple)
- *Echinochloa colona* (Awnless Barnyard Grass)
- *Eragrostis amabilis* (Awnless Barnyard Grass)
- *Flaveria trinervia* (Speedy Weed)
- *Lolium multiflorum* (Italian Ryegrass)
- *Lysimachia arvensis* (Pimpernel)
- *Malvastrum americanum* (Spiked Malvastrum)
- *Setaria verticillata* (Whorled Pigeon Grass)
- *Sisymbrium erysimoides* (Smooth Mustard)
- *Sisymbrium orientale* (Indian Hedge Mustard)
- *Sonchus oleraceus* (Common Sowthistle)
- *Tribulus terrestris* (Caltrop)
- *Vachellia farnesiana* (Mimosa Bush)

Two species are listed as Declared Pests under the WA *Biosecurity and Agriculture Management Act 2007* (BAM Act): *Argemone ochroleuca* (Mexican Poppy); and *Datura leichhardtii* (Native Thornapple) are classified as C3 (management) for the Upper Gascoyne. Under the BAM Act, C3 organisms should have some form of management applied that will alleviate the harmful impact, reduce the numbers or distribution, or prevent/contain the spread of the pest.

None of the introduced species recorded in the study area are included on any of the weed lists maintained by the Department of the Environment and Energy, nor Weeds Australia.

Only one introduced species, *Malvastrum americanum* (Spiked Malvastrum), rates above 'moderate' according to the Weed Prioritisation Process for DPaW (WA) Midwest rankings summary (2013 in Ecoscape 2015). The Spiked Malvastrum is classified as 'very high'.

ERICA

The ERICA Software Tool is used for assessing radiological impacts to plants and animals. The software uses the change in media radionuclide concentrations and concentration ratios in species, derived from studies, to provide a measure of radiological impact to a number of reference species. The intake of radionuclides is a function of the quantity of radionuclides in the soil and the rate of uptake. For this ERICA assessment (JRHC 2016; Appendix 5-6), the maximum media concentration was used and a Tier 2 level assessment was undertaken.

The assessment method produces a dose rate, which is compared to a 'screening level'. This is the level below which no effects would be observed. The default ERICA level is set at 10 µGy/h (ARPANSA 2010). The output of the assessment showed that a 10 µGy/h screening level was not exceeded. The species with the highest level of exposure was lichen and bryophytes (0.014 µGy/h), however the exposure level remains well below the trigger level for further assessment. The level of exposure for grasses and herbs was 0.005 µGy/h and trees were less than 0.001 µGy/h.

5.2.3 Potential impacts

Potential impacts include:

- Clearing approximately 1,000 Ha of native vegetation.
- Clearing beyond approved footprint.
- Direct loss of Priority flora species.
- Increased fire hazards as a result of mine site activities resulting in potential for fire to temporarily impact vegetation. It should be noted that this may positively impact some flora species.
- Changes to surface and groundwater quality potentially impacting vegetation (discussed further in Section 5.5).
- Altered surface water flow during heavy rainfall events impacting vegetation downstream (discussed further in Section 6.3).
- Introduction, establishment and spread of weed species.
- Indirect impacts of dust from vehicle movements.
- Indirect impacts from uptake of radionuclides (discussed further in Section 5.6).

5.2.4 Assessment of impacts

The Proposal will not impact any conservation significant flora species or threatened ecological community, and will not change the conservation status of the two Priority flora species occurring within the Proposal area:

- *Acacia curryana;* and
- *Rhodanthe frenchii*.

A total of 192 *Acacia curryana* individuals occur within the development envelope. A total of 7,754 plants were recorded within the broader tenement areas. This represents an impact of 1.18% of the total recorded population in the tenement area.

A total of 53 *Rhodanthe frenchii* individuals occur within the development envelope. A total of 1,690 plants were recorded within the broader tenement areas. This represents an impact of 3.13% of the total recorded population in the tenement area.

None of the mapped vegetation types are restricted to the proposed development footprint. Vegetation type AtGc has the highest proportion of its total extent within the proposed development footprint (31.0%), followed by EeAc (9.9%) and ApSgAc (2.5%). All other vegetation types have less than 1.5% of their total extent within the development envelope. Ten of 20 mapped vegetation types in the tenement area are not represented in the development envelope (Table 7 of Appendix 1-1).

The one vegetation type (EcMgCc), which represents a Groundwater Dependent Ecosystem (GDE), is not recorded within the development envelope due to a 150m exclusion buffer on either side of the Lyons River and Frasers Creek. Two vegetation types, EvCc and AcEt, that may represent GDEs have 0.06% and 3.08% of their mapped extent occur within the development envelope, respectively.

As a result of pit dewatering potential water drawdown impacts may occur to the potential GDEs, specifically vegetation type AcEt (characterised as potential GDE due to the presence of *Eucalyptus vitrix*) which intersects the modelled post mining drawdown in the immediate surrounds (**Figure 6**): 19.05 ha at Bald Hill, 22.09 ha at Frasers and 100.61 ha at Yangibana (total of 141.74 ha). Ecoscape (2017; Appendix 1-3) reports:

The AcEt vegetation type is primarily dominated by Acacia cyperophylla which is not known or considered to be a groundwater dependant species. This vegetation type was only occasionally observed to contain scattered or isolated individuals of Eucalyptus victrix; more commonly this species was absent. Therefore, it is considered unlikely that the AcEt vegetation type represents a groundwater dependant ecosystem, at least in most cases. The potential impact of post mining groundwater drawdown on GDE's is therefore considered likely to be negligible or nil.

Furthermore, flora and vegetation surveys have not been conducted over areas of the development envelope south of the Lyons River at the location of the access road. This is due to recent realignments of the access road. This poses a risk that conservation significant species or ecological communities occur in the area. Despite this future surveys will be conducted and due to the extent of the development envelope, a commitment can be made to realign the access road, where necessary, to avoid impacts to rare or newly discovered species.

A desktop assessment has been completed by Ecoscape (2017; Appendix 1-2), which highlights one of four vegetation associations that are not analogous to those found in the previous studies, although they are all mulga shrublands. Regardless, a survey of the area will be undertaken prior to construction activities to determine whether or not rare or newly discovered species occur within the proposed disturbance footprint and will adjust the road alignment to avoid those individuals.

A level 2 ERICA assessment was conducted to determine radiological impacts to flora and vegetation. The ERICA assessment indicates that there is no radiological risk of impact on reference plants from potential emissions from the Proposal.

5.2.5 Mitigation

Hastings commits to the following mitigation of potential impacts:

BEST PRACTICE

- Minimise land disturbance to meet operational requirements only.
- Progressive rehabilitation where possible.

AVOIDANCE

- Avoid clearing populations of conservation significant species, where possible.
- 150 m exclusion zone on either side of Fraser Creek and Lyons River.

MINIMISATION

- Groundwater abstraction from fractured rock aquifers is self-limiting.
- Water reuse to reduce the water requirements of the Proposal.

<u>Management</u>

- Topsoil stockpile management to retain viability of local provenance native seedbank.
- Flora and vegetation management plan, including:
  - management of existing weeds and prevention of the introduction and establishment of weed species (not currently present in the development envelope);
  - ground disturbance procedure to ensure delineation of clearing boundaries and topsoil management;
  - dust suppression; and
  - fire prevention, with reference to bush fire management procedures in the Emergency Response Plan.

<u>Rehabilitation</u>

Implementation of progressive rehabilitation will occur, where possible, during the operational phase of the Project. While progressive rehabilitation and closure will be prioritised, the short life of mine and sequential nature of mining deposits will limit these opportunities to exploration activities, WRLs, final voids and associated disturbance, following the cessation of mining activity in each area. Disturbance associated with exploration activities also represents opportunities for progressive rehabilitation.

Progressive rehabilitation will enable opportunities to undertake trials, reduce the Project's financial liability under the Mining Rehabilitation Fund (MRF), and demonstrate to key stakeholders Hastings commitment to meet the social and environmental licence to operate.

- Progressive rehabilitation implemented as determined in the Preliminary Mine Closure Plan (Appendix 6) including the following considerations:
  - Topsoil and subsoil storage and locations in preparation for progressive rehabilitation.
  - Progressively shape, contour and spread suitable soils on WRLs.
  - Establish diversion drains at the toe of the WRLs.
  - Rehabilitation of auxiliary roads that are no longer in use.
  - Rehabilitation of drill pads that are no longer in use including capping of holes, sumps backfilled, soil ripped and reseeded.

5.2.6 Predicted outcome

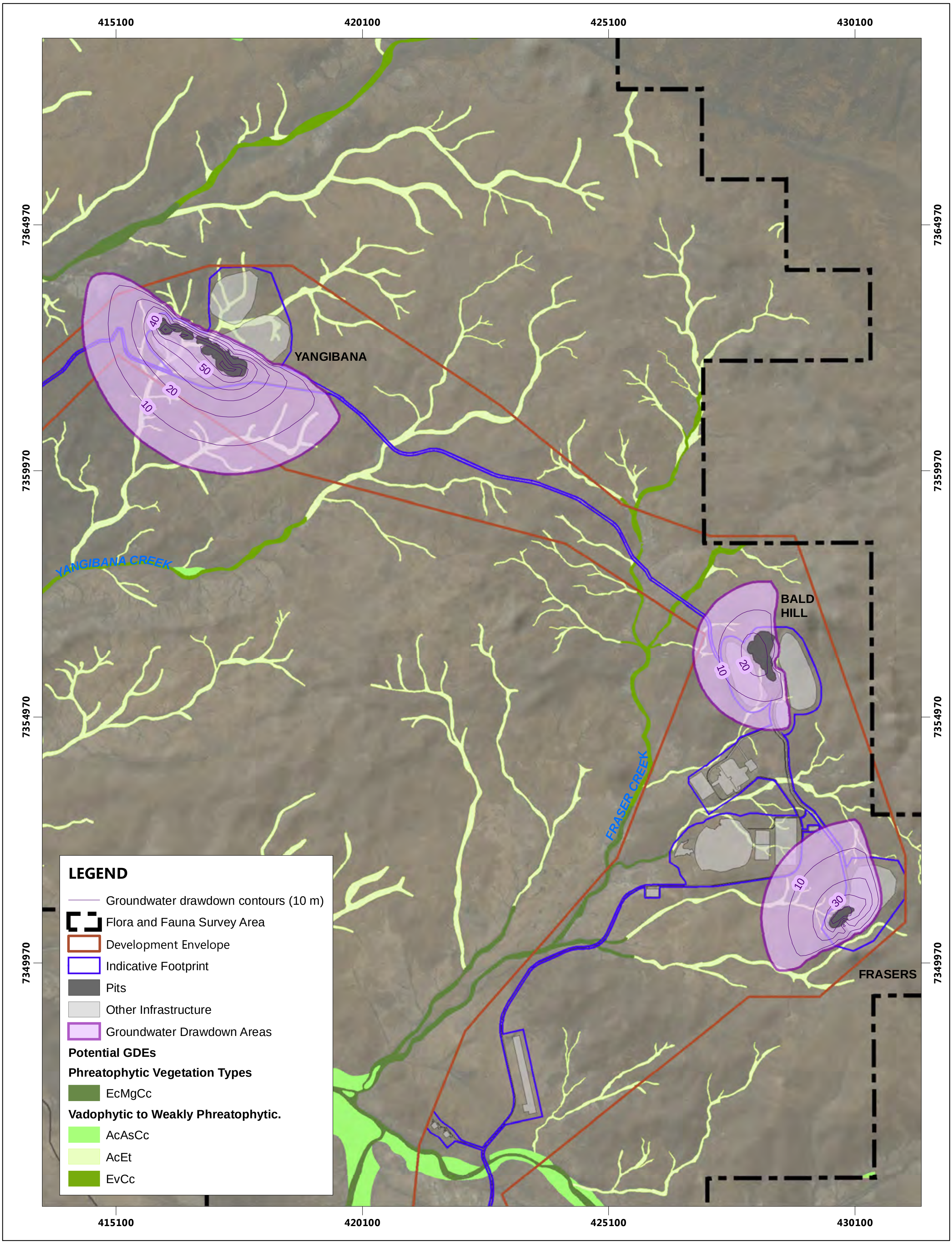
Following the mitigation of potential impacts, it is expected that no more than 1000 Ha of vegetation will be cleared.

No impacts to rare flora species will occur. Direct impact to two priority flora species is considered insignificant: Only 1 % and 3 % of *Acacia curryana* and *Rhodanthe frenchii* plants, respectively, will be disturbed within the tenement area.

There are no Threatened Ecological Communities present nor Priority Ecological Communities (as defined by vegetation associations). No regional vegetation associations will be cleared below the 'threshold level' of 30% of its pre-clearing extent.

As a result, the EPA's objective has been met for this environmental factor:

To protect flora and vegetation so that biological diversity and ecological integrity are maintained.



SCALE: 1:100,000 @ A4

COORDINATE SYSTEM: GDA 1994 MGA ZONE 50
PROJECTION: TRANSVERSE MERCATOR
DATUM: GDA 1994
UNITS: METER
DATA SOURCES:
SERVICE LAYERS: SOURCE: ESRI, DIGITALGLOBE, GEOEYE, I-CUBED, USDA, USGS, AEX, GETMAPPING, AEROGRID, IGN, IGP, SWISSTOPO, AND THE GIS USER COMMUNITY

ecoscape

PROJECT NO: 3402-15

REV	AUTHOR	APPROVED	DATE
0	JN	ERR	25/01/2017

N 0 1 2 3 km

POST MINING GROUNDWATER DRAWDOWN AND GDES

YANGIBANA RARE EARTHS PROJECT

CLIENT: HASTINGS

FIGURE 06

5.3 KEY ENVIRONMENTAL FACTOR 2: SUBTERRANEAN FAUNA

5.3.1 EPA objective

To protect subterranean fauna so that biological diversity and ecological integrity are maintained.

5.3.2 Policy and guidance

Laws and regulations relevant to the consideration of subterranean fauna include:

> *Environmental Protection Act 1986* (WA)

Relevant guidelines include:

> EPA (2002) Protection Position Statement No. 3: Terrestrial biological surveys as an element of biodiversity;
>
> EPA (2007) Guidance Statement No. 54A: Sampling methods and survey considerations for subterranean Fauna in Western Australia (Technical Appendix to GS 54);
>
> EPA (2013) Environmental Assessment Guideline (EAG 12): Consideration of subterranean fauna in environmental impact assessment in Western Australia;
>
> EPA (2016k) Environmental Factor Guideline: Subterranean fauna;
>
> EPA (2016o) Technical Guidance - Subterranean fauna survey.

5.3.3 Receiving environment

The following studies have informed this section:

- Subterranean Fauna Report (Ecoscape 2015; Appendix 3-1)
- Regional Subterranean Fauna Report (Bennelongia 2017; Appendix 3-2)
- Conceptual Hydrogeological Assessment (Global Groundwater 2016; Appendix 4-1)
- Hydrogeological Assessment (GRM 2017; Appendix 4-2)

A DPaW listed Priority Ecological Community (PEC) occurs within the study area, and the development envelope intersects the northern portion of this PEC. The PEC is listed as:

> *Priority 1 (P1) Gifford Creek, Mangaroon, Wanna calcrete groundwater assemblage type on Lyons palaeodrainage on Gifford Creek, Lyons and Wanna Stations.*

DPaW refer to the PEC as the "Gifford Creek Calcrete PEC", which comprises unique assemblages of invertebrates (stygofauna) that have been identified in the groundwater calcretes.

Stygofauna and troglofauna occur within the proposed mineral deposits in the development envelope.

STYGOFAUNA

Stygofauna samples of eight drill holes within the development envelope initially found 236 stygofauna specimens from four families representing 10 species (Ecoscape 2016). Additional subterranean fauna surveys within the broader PEC area have found that a greater diversity and abundance of stygofauna species are represented within the calcretes of the PEC (Bennelongia 2017; Appendix 3-2). A total of 830 specimens from 57 discrete species of stygofauna were recorded from the Project and surrounding region during surveys conducted in 2016. Reference sites yielded 730 specimens, including all 57 species, while impact areas yielded 100 specimens from 6 species. Combining results from current and previous studies, the total number of stygofauna species known from the broader Gifford Creek PEC study area is at least 62, but is highly likely to increase with further sampling.

Major groups present include flatworms (Turbellaria), earthworms (Oligochaeta), rotifers (Rotifera), nematode roundworms (Nematoda), ostracods (Ostracoda), copepods (Cyclopoida and Harpacticoida), amphipods (Amphipoda), isopods (Isopoda), aquatic mites (Arachnida: Acari) and beetles (Insecta: Coleoptera). Six of the ten stygofauna species recorded in the previous Ecoscape (2016) survey were also recorded in the current survey (Ameiridae gen. nov. sp. B04, *Diacyclops cocking*, *Diacyclops humphreysi humphreysi*, Paramelitidae sp. B49, Phreodrilidae `with dissimilar ventral chaetae` and Nematoda sp.), while four species (*Orbucyclops westraliensis*, *Areacandona* sp. BOS550, *Enchytraeus* sp. 1 (PSS) Pilbara and *Phreodrilus peniculus*) were not recollected.

TROGLOFAUNA

Initial surveys (Ecoscape 2016) of six drill holes within the development envelope recorded 11 troglofauna specimens from five orders representing at least five separate species:

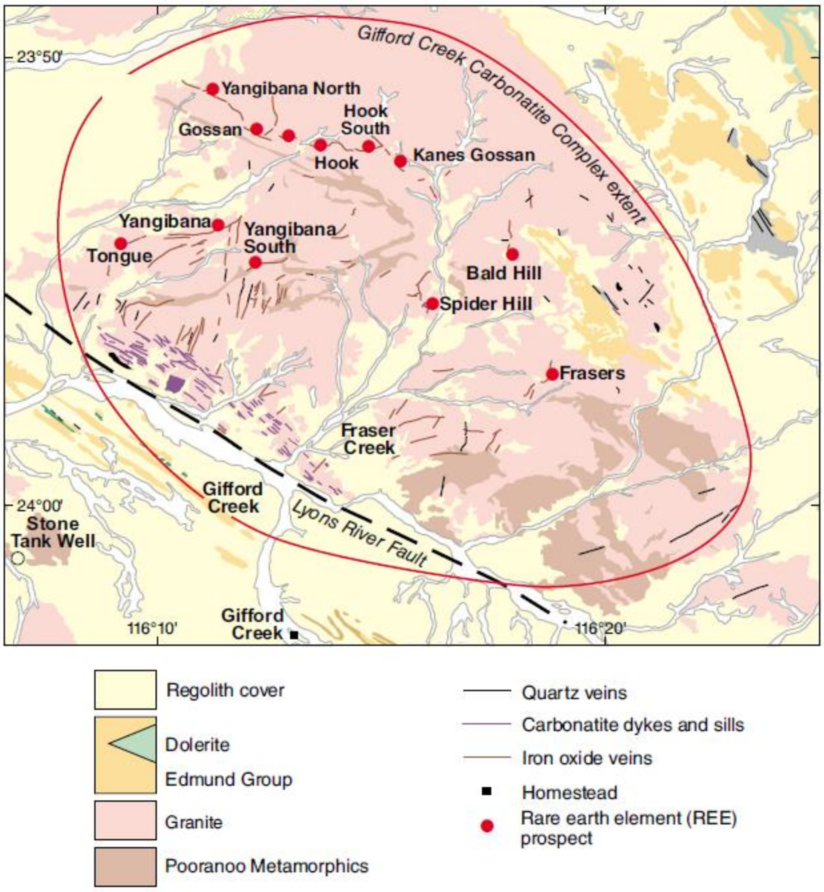
- *Troglarmadillo* sp. B60
- *Projapygidae* sp. B19
- *Trinemura* sp. B29
- *Geophilida* sp.
- *Scutigerella* sp. B09.

All of the troglofauna records were considered likely to be of conservation concern. Further surveys were conducted and found a total of 16 specimens representing 10 distinct species of troglofauna were recorded across 10 drill holes in the study area in 2016 (Bennelongia 2017). After appropriately aligning historic (Ecoscape 2016) and current results, there are at least 13 species of troglofauna known from the study area, including a palpigrade, two isopods, three centipedes, a millipede, a symphylan, two diplurans, a sciarid fly, a meenoplid bug and a silverfish. At least six of these species are considered likely to be restricted to the study area, although assessments of endemism are limited by unresolved taxonomy in many groups. Two taxa recorded in the current survey may taxonomically align with previously recorded species and are not currently considered to represent discrete species: *Scutigerella* sp. may belong to *Scutigerella* sp. B09; and *Trinemura* sp. may belong to *Trinemura* sp. B29 (Ecoscape 2016). Overall, the Project appears to harbour a troglofauna community of low-to-moderate diversity.

HABITAT ANALYSIS

Habitat analysis indicated that there is no obvious link between the preferred calcrete habitats of stygofauna as found in the PEC and the occurrence of subterranean fauna within the Proposal area. Geological drill logs and datasets have shown that calcrete is not present within the mineral exploration areas of the Proposal, indicating that subterranean fauna habitat is not typical of that recorded from PEC calcrete areas, although it may overlap and be representative of that on the fringes of the Gifford Creek PEC.

Holes in four deposit areas yielded troglofauna – Frasers, Gossan, Yangibana North and Yangibana West. Underlying geology of these deposits is largely granite and granitoid rock (PLgpi), with some unconsolidated ferruginous rubble and scree (C1f) present at Frasers (Ecoscape 2016). Troglofauna were also collected from the Bald Hill and Kanes Gossan deposits by Ecoscape (2016) but were not recorded there in the current survey. Bald Hill geology comprises granites (PLgpi and PLgpix) and unconsolidated units (C1f), while geology at Kanes Gossan largely comprises granite (PLgpi) (Ecoscape 2016). Additionally, the troglofaunal hemipteran *Phaconeura* sp. was collected from calcrete in a stygofauna sample in the regional reference site No. 1 Bore. Granite and granitoid units occur widely throughout the study area and may provide suitable habitat for troglofauna in areas that are not proposed for development (as shown in **Figure 7**).



Pirajno and Gonzalez-Alvarez, 2013

Figure 7 Simplified geology of the Gifford Creek Ferrocarbonatite Complex

5.3.4 Potential impacts

Potential impacts include:

- Direct loss of subterranean fauna species and associated habitat (101.5 Ha) from mining.
- Potential indirect and temporary impacts to habitat in the immediate vicinity of pit dewatering activities.
- Potential indirect impacts to PEC habitat as a result of changes to surface and groundwater quality (discussed further in Section 4.5).

5.3.5 Assessment of impacts

A direct impact will occur due to the association of subterranean fauna with the target ore body to be mined. However, the proposed deposits cover a total of approximately 101.5 Ha of the mapped PEC, which equates to 0.034% of the total PEC area.

STYGOFAUNA

As a result of pit dewatering potential temporary impacts may occur to low-value stygofauna fauna habitat in the immediate surrounds. All stygofauna species known from the Project area have been recorded in areas outside the conservative 1 m drawdown contour inferred from hydrological modelling by GRM (2017). One-metre drawdown contours associated with proposed developments were considered appropriate delineators between reference and impact areas because (a) the occurrence of calcrete in the immediate vicinity of proposed development areas is low, meaning that drawdown affecting calcrete aquifers will be relatively insignificant in the regional context; and (b) the likely depth and volume of calcrete aquifers in the vicinity of proposed development areas means that substantial stygofauna habitat would remain intact outside the 1 m drawdown contour (Bennelongia 2017; **Figure 8**).

Geologies of the proposed excavation areas at the Bald Hill, Frasers, Yangibana North and Yangibana West largely comprise consolidated granite and granitoid units (PLgpi) that are generally unconducive to stygofauna (i.e. as reflected by significantly fewer animals and species per sample compared to the reference areas). Furthermore, stygofauna species recorded in impact areas were also collected in reference areas, and are common species that are known to be widespread outside the study area (Bennelongia 2017).

It is considered unlikely that dewatering, excavation and other mine-related activities at the Proposal will have any impact on the conservation value of stygofauna communities or individual stygofauna species.

<u>TROGLOFAUNA</u>

The primary mine-related factor contributing to the loss of troglofauna habitat is mine pit excavation. In the case of proposed mining operations at the proposal, pit excavations are the only proposed operations that will result in significant loss of troglofauna habitat.

Four troglofauna species were only recorded from inside proposed pit boundaries, however it is considered highly likely that two of these, the centipedes Chilenophilidae sp. and Schendylidae sp., occur outside the impact areas. Both species were recorded from separate pits and have known linear ranges of approximately 17 km, with collection locations interspersed by reference areas with similar granite geologies to collection locations. These centipede species are not currently considered to be of conservation concern.

The dipluran Parajapygidae sp. B41 and the isopod Troglarmadillo sp. B60, which are both considered likely to be short-range endemics, remain known only from inside proposed pit boundaries and their occurrence outside these areas remains speculative:

- Parajapygidae sp. B41 was collected from two holes in the Yangibana North deposit and has a known linear range of approximately 0.25 km. Six impact holes and no reference holes were surveyed at the Yangibana North deposit.
- Troglarmadillo sp. B60 was recorded as three individuals from a single hole in the Frasers deposit, where a total of 5 reference and 7 impact holes have been surveyed for troglofauna.

Both Parajapygidae sp. B41 and Troglarmadillo sp. B60 are likely to occur in reference areas because:

- Granite and granitoid (PLgpi) geologies similar to those at collection locations occur extensively in reference areas outside proposed development areas. This suggests that habitat suitable for both species probably occurs in reference areas.
- The presence of troglofauna at the Gossan and Kanes Gossan deposits, which are not currently proposed for development, shows that prospective troglofauna habitat occurs in granite units outside of proposed development areas.
- Yield rates for troglofauna sampling, including yields of troglofauna in stygofauna samples, were very low, suggesting either low troglofauna population densities, a high degree of sampling difficulty, or a combination of both these limiting factors. It is

inferred that sampling effort was insufficient to collect further specimens of Parajapygidae sp. B41 or Troglarmadillo sp. B60.

Beyond the direct impacts, there is the potential for the Proposal activities to have indirect impacts on the troglofauna, stygofauna and their habitat: Surface and groundwater quality has the potential to impact the calcrete aquifer network associated with the PEC (discussed further in section 5.5). Although limited hydrogeological connectivity makes these potential indirect impacts unlikely to change the conservation status of individual species, their habitat or the broader Gifford Creek PEC.

5.3.6 Mitigation

Hastings commits to the following mitigation of potential impacts:

Best Practice

- Site-wide water reuse

Avoidance

- No groundwater abstraction from the Gifford Creek calcrete aquifers.
- No significant groundwater abstraction from an aquifer with direct hydraulic connection to the Gifford Creek Calcrete PEC.

Minimisation

- Limit groundwater abstraction to meet operation requirements only.
- Water collection and re-use from processing plant, where possible.
- Processing plant, evaporation pond and TSFs located outside of the flood plain.

Management

- Containment and secondary bunding around all facilities with chemicals and hazardous waste.
- Surface water management at the process plant, evaporation pond and tailings storage facilities (TSF), including:
  - the evaporation pond, and appropriate collection bunds and channels will be used to manage potentially contaminated surface water runoff;
  - the containment of surface water runoff, associated with a significant rainfall event, around the ROM, processing plant and TSF 2 and 3; and
  - maintaining adequate freeboards to manage unforeseen events.
- Spill management procedures.
- Implement the Radiation Waste Management Plan (Appendix 5-7).
- Surface water and groundwater monitoring.

Rehabilitation

- Cessation of water abstraction activities at closure will result in the rebound of the water table towards pre-mining levels, reintroduction of natural geohydrology patterns and return of subterranean fauna habitat.

5.3.7 Predicted outcome

Loss of 101.5 Ha of subterranean fauna habitat will occur as a result of mining. This represents less than 0.05% of the Gifford Creek PEC footprint.

Given there is limited hydrogeological connectivity with the broader calcrete aquifer network of the Gifford Creek PEC, it is unlikely that impacts to groundwater quality and quantity have the potential to impact the diversity and ecological integrity of the PEC. The mitigation described above will also reduce the likelihood of potential indirect impacts associated with the Proposal.

Both troglofauna and stygofauna habitat occur well beyond the Proposal pit footprints and thus the Proposal will meet the EPA objective for this environmental factor:

To protect subterranean fauna so that biological diversity and ecological integrity are maintained.

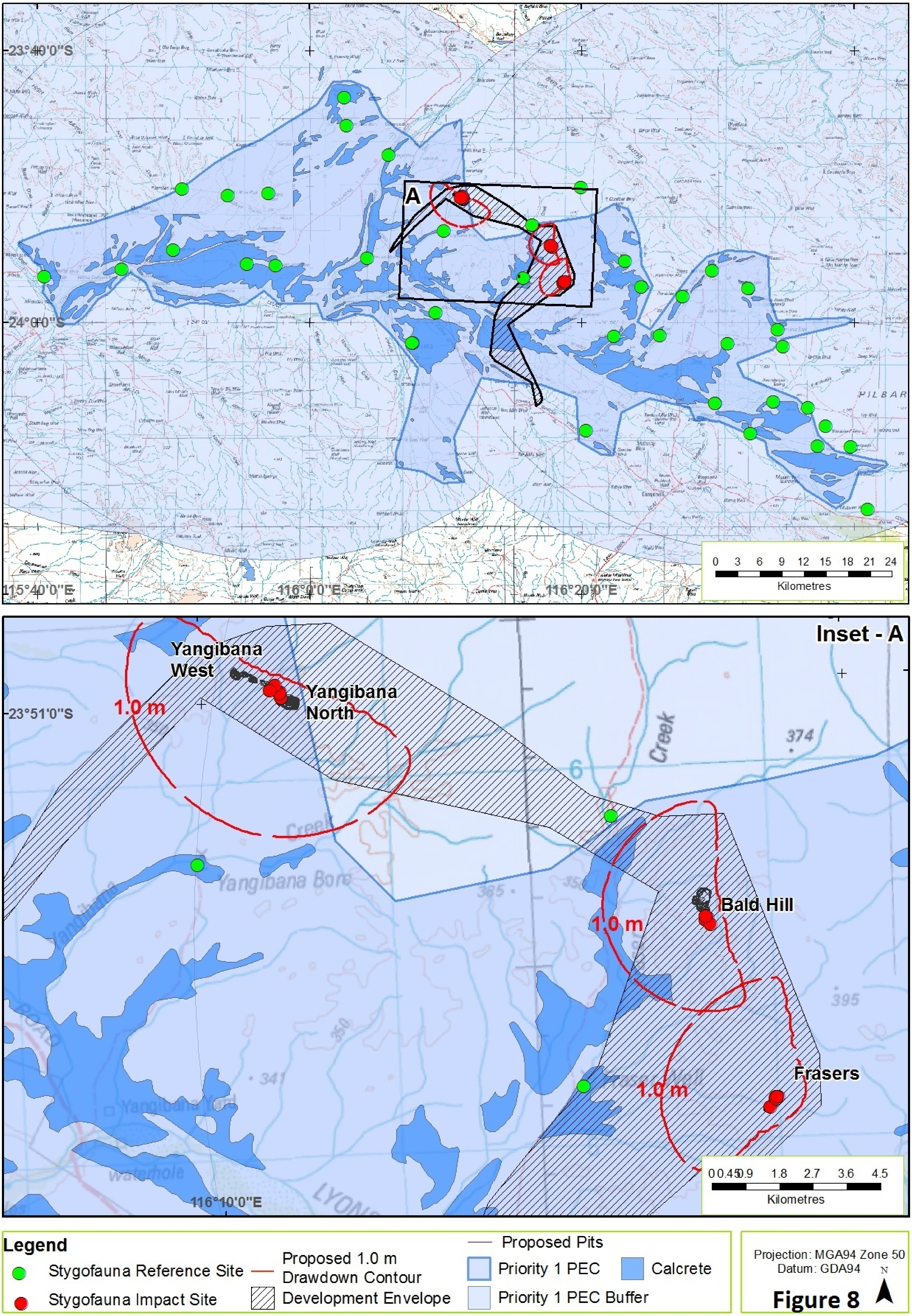

23°40'0"S
24°0'0"S
115°40'0"E
116°0'0"E
116°20'0"E
A
0 3 6 9 12 15 18 21 24
Kilometres
Inset - A
Yangibana West
Yangibana North
1.0 m
23°51'0"S
Creek
Yangibana Bore
Bald Hill
Frasers
116°10'0"E
0 0.45 0.9 1.8 2.7 3.6 4.5
Kilometres
Legend
Stygofauna Reference Site
Stygofauna Impact Site
Proposed 1.0 m Drawdown Contour
Development Envelope
Proposed Pits
Priority 1 PEC
Priority 1 PEC Buffer
Calcrete
Projection: MGA94 Zone 50
Datum: GDA94
N

Figure 8

5.4 Key environmental factor 3: Terrestrial environmental quality

5.4.1 EPA objective

To maintain the quality of land and soils so that environmental values are protected.

5.4.2 Policy and guidance

Laws and regulations relevant to the consideration of terrestrial environment quality include:

Australian Radiation Protection and Nuclear Safety Act 1998 (Commonwealth)

Contaminated Sites Act 2003 (WA)

Dangerous Goods and Safety Act 2004 (WA)

Environmental Protection Act 1986 (WA)

Health Act 1911 (WA)

Mines Safety and Inspection Act 1994 (WA)

Mining Act 1950 (WA)

Radiation Safety Act 1975 (WA)

Soil and Land Conservation Act 1945 (WA)

Relevant guidelines include:

ANCOLD (2012) Guidelines on Tailings Dams - Planning, Design, Construction, Operation and Closure;

ANCOLD (2012) Guidelines on the Consequence Categories for Dams;

ARPANSA (2005) Code of Practice for Radiation Protection and Radioactive Waste Management in Mining and Mineral Processing (the Mining Code);

Australian Government Department of Industry, Tourism and Resources (2007) Tailings Management: Handbook in the Leading Practice Sustainable Development Program for the Mining Industry Series;

DER (2014) Assessment and Management of Contaminated Sites: Contaminated Sites Guidelines;

DMP (1998; prev. DME) Guidelines on the Development of an Operating Manual for Tailings Storage;

DMP (2010) Managing naturally occurring radioactive material (NORM) in mining and mineral processing guideline (2nd edition). NORM 4.1 Controlling NORM – dust control strategies;

DMP (2010) Managing naturally occurring radioactive material (NORM) in mining and mineral processing guideline (2nd edition). NORM-4.2 Controlling NORM – management of radioactive waste. Resources Safety, Department of Mines and Petroleum;

DMP (2013) Code of Practice - Tailings storage facilities in Western Australia. Resources Safety and Environment Divisions;

DMP (2013) Guidelines on the Safe Design and Operating Standards for Tailings Storage;

DMP (2015) Guide to the Preparation of a Design Report for Tailings Storage Facilities;

DMP and EPA (2015) Guidelines for Preparing Preliminary Mine Closure Plans;

DoW (2009) Water quality monitoring program design: A guideline for field sampling for surface water quality monitoring programs;

EPA (2003) Guidance Statement 55 - Implementing best practice in proposals submitted to the environment impact assessment process;

EPA (2006) Guidance for the Assessment of Environmental Factors No. 6 – Rehabilitation of Terrestrial Ecosystems;

EPA (2016l) Environmental Factor Guideline: Terrestrial Environmental Quality; and

IAEA (2006) Storage of Radioactive Waste: Safety Guide.

5.4.3 Receiving environment

The following studies have informed this section:

- Waste Characterisation Report (Trajectory 2016; Appendix 5-1)
- Soils Assessment Report (Landloch 2016a; Appendix 5-2)
- Baseline Radiation Report (RadPro 2016a; Appendix 5-4)
- Radiation Waste Characterisation Report (RadPro 2016b; Appendix 5-5)
- Radiation Impact Assessment (JRHC Enterprises 2016; Appendix 5-6)
- Conceptual Hydrogeological Assessment (Global Groundwater 2016; Appendix 4-1)
- Hydrogeological Assessment (GRM 2017; Appendix 4-2)
- Geotechnical Assessment (ATC Williams 2017; Appendix 5-9)
- Preliminary Landform Surface Erodibility Assessment (Landloch 2016b; Appendix 5-3)

LAND USE

The predominant land use in the Upper Gascoyne region, and in the immediate vicinity of the proposed development envelope, is cattle grazing. Current impacts to the terrestrial environment exist from historic grazing, most evident along stream banks where cattle access water.

GEOLOGY

The geology of prospects within the proposed development envelope contain the phosphate mineral monazite which contains low levels of thorium and uranium and their decay progeny in approximate secular equilibrium. The presence of these elements is termed Naturally Occurring Radioactive Materials (NORM) as they are derived from a geological source associated with the granite bedrock and successive hydro-thermal emplacement of ferrocarbonatite (ironstone) dykes. The target ore body occurs within the ferrocarbonatite dykes.

SOILS

Two predominant soil types have been mapped within the Proposal development envelope area (Landloch 2016a; Appendix 5-2), both of low fertility:

Hill soils - associated with the granite low hills and rises of the site. Soil depths vary from shallow near hill tops (adjacent to rock outcrops or more sloping hills) to 40-50cm on lower hill flanks. Hill Soils are dark brown sandy duplex soils and con be divided into an A and B horizon that overlies a C horizon of decomposing granite. The Hill Soil has a neutral to slightly acidic pH, very low salinity levels (ECi<0.02dS/m) and a maximum exchangeable sodium percent (ESP) of 4.7%.

Plain soils - associated with the low relief areas and flood plains of the drainage lines. A thin surface sandy loam topsoil overlies a silty loam subsoil. These soils are located in areas of recent deposition and will be influenced by the nature and frequency of past flooding events, and the character of the contributing catchment. The Plain Soils tend to be shallow (<30cm), but the depth of refusal and hence the reported soil depth is a function of the clay hardpan encountered. The Plain Soil is a dark brown sandy loam over clay loam. The soil has a massive structure (i.e. weak), strongly alkaline, saline (ECi 5 0.55 - 9.35dS/m), and sodic (ESP 2.85 - 33.96%).

WASTE CHARACTERISATION

Waste rock

The primary waste lithologies, which will be mined in large quantities and hence form part of the waste management and landform design strategy are ironstone, fresh granite, transitional granite/ironstone (saprock) and weathered granite (saprolite). All Project mine pit lithologies have been characterised geochemically and classify as Non Acid Forming (NAF; Trajectory and Graeme Campbell 2016; Appendix 5-1). Sulphide-S forms are consistently absent as indicated by Total-S values less than 0.1 % (and generally less than 0.01 %). Gypsum-S may occur locally within the range 0.1-1.5 % in the surficial colluvium and waste-saprolite-zone. However, this is 'benign-S' and the gypsum-Ca has the effect of suppressing clay dispersion. Enrichments in minor-elements are modest, reflective of the lack of sulphide-minerals.

A proportion of the waste rock inventory (approximately 8-9%) has slightly elevated naturally occurring radionuclide levels. These zones are thought to be generally proximal to the orebody, primarily in the ironstone.

The mineralogy of the project is not associated with asbestiform minerals.

Erodibility parameters were determined for plain soils, hill soils, ironstone, surface granite and weathered granite (Landloch 2016; Appendix 5.3). The plain and hills soils represent topsoil which may be a suitable plant growth media. The ironstone, surface granite and weathered granite are representative of the waste materials in the waste rock landform and collected from surface and subsurface areas. However, the majority of waste will be fresh granite, which is found at depth and this was not tested in the erodibility assessment due to its competent nature. The erosion potential of the soils tested showed that erosion reaches high rates at very short slope lengths, and then remains high as length of slope increases. Mixing soil and rock reduced the potential for erosion but were detachment limited i.e. potential for erosion remains low for a longer length of slope but then increases rapidly as water accumulation causes detachment of particles within rills.

Tailings

There will be three tailings streams generated from processing of the ore. Bench scale tailings have been produced and these have undergone preliminary characterisation (Trajectory and Graeme Campbell 2016; and RadPro 2016b; Appendices 5-1 and 5-5, respectively).

The first stream of tailings from the beneficiation process is to be disposed in TSF 1. These tailings will be benign geochemically (i.e. NAF). There were slight enrichments of metals in both the tailings solids and contact waters that were analysed. TSF 1 tailings have radionuclide readings of < 1 Bq/g (RadPro 2016b; Appendix 5-5).

The second stream of beneficiation tailings (to be disposed in TSF 2) are benign geochemically (i.e. NAF). Slight to moderate enrichments of metals were reported in both tailings solids and contact waters that were analysed. TSF 2 tailings will have radionuclide levels of 7 Bq/g. Radionuclides will not be water soluble in these tailings.

TSF 3 tailings-solids are also expected to be NAF, though strongly gypsiferous (Total-S ca. 10 %), due to neutralisation of the acidic raffinate with calcite. The tailings may be slow / difficult to drain and consolidate to a trafficable surface. TSF 3 radionuclide levels of 24 Bq/g are water soluble due to the 'cracking' of the rare earths elements concentrate during the baking and sulphuric acid treatment in the hydrometallurgy process.

RADIONUCLIDES

Baseline gamma levels have been determined via three methods; handheld instrument gamma surveys, integrating monitors and interpretation of an aerial radiometric survey (RadPro 2016a; Appendix 5-4). The monitoring shows that gamma levels are elevated above mineralisation as expected, which is associated with the outcropping ironstone. Average gamma dose rates are 0.23 $\mu Gy.h^{-1}$ in areas away from the outcropping mineralization. Average gamma dose rates are 0.37 $\mu Gy.h^{-1}$ over the deposit areas and range up to 1.26 $\mu Gy.h^{-1}$.

Baseline environmental dust sampling was conducted across the project area, from 2015 onwards, using low volume pumps (SKC AirLite and SKC Airchek 52) to collect samples over a period of at least four hours (RadPro 2016b). Airborne alpha activity concentrations are similar for all areas of the Proposal, both over the prospects and in areas away from radiologically enhanced mineralization. The average airborne activity on and off the deposit was 0.01 and 0.009 $\alpha dps.m^{-3}$, respectively.

Baseline radon and thoron monitoring, commenced in 2015 using Landauer Radtrak devices, which were placed at four locations around the Project areas, with one pair measuring a background location at Gifford Creek Station Homestead, approximately 20 km south of the Project area. Monitors were placed in pairs, one measuring radon only and the other measuring radon and thoron. Monitors were replaced at intervals determined by access to site, and exposure periods have ranged from 144 days up to 173 days.

Many of the radon-only monitors returned results below the minimum detection level (MDL). For estimation of values for radon and thoron concentrations, it was assumed that any result below the MDL is equivalent to the MDL value.

Both subsurface and topsoil samples were collected and analysed for uranium and thorium. Subsurface samples were taken from eight drill holes below the surface, within or immediately adjacent to mineralisation and were selected to be approximately representative of the Proposal target resource material. Samples were analysed for total uranium and thorium, and by gamma spectroscopy (ESR) for members of each decay chain. Analysis shows that concentrations of uranium and thorium in mineral samples vary widely. Comparison with the wider data set indicated that higher concentrations of radionuclides are found with the target REE in mineralised areas compared to surrounding granites and metamorphics. The uranium and thorium concentrations in topsoil were 0.368 mg/kg and 7.87 mg/kg, respectively.

5.4.4 Potential impacts

Potential impacts include:

- Potential dispersion of saline, sodic soils associated with disturbance of plains soils.
- Potential contamination of surrounding soil and land as a result of:
    - Potential dust generation from ROM pad, processing plant and TSFs.
    - Seepage of tailings water.
    - Potential operational leaks and spills.
    - Contaminated surface water.
    - Potential failure of TSF integrity.

- Potential erosion of waste rock landform (WRL) surfaces.

5.4.5 Assessment of impacts

Plains soils have the potential to impact surrounding lands and soils. Hill soils are also erosive but do provide a suitable growth medium for rehabilitation of disturbed surfaces.

Dust generation from the 'wet' processing plant is unlikely. All TSFs will be maintained in a 'wet' state during operations and will be capped during closure. Dust generation from TSF 1 is likely to be geochemically benign. Dust generation at the ROM pad has the potential to impact the surrounding lands and soils.

Elevated radionuclides in two of three tailings waste streams has the potential to impact the quality of surrounding land and soils if TSF designs do not occur in accordance with policy and guidance (listed above in section 5.4.2). A geotechnical assessment has been conducted over the return water pond, TSFs, and evaporation pond areas (ATC Williams 2017; Appendix 5-9):

- Return water pond: Bore holes were placed at the toe of TSF1 and in the return water pond areas. The soils in this location consisted of superficial soils (i.e. clay, clay gravel and clayey sand) up to 1.15 m below ground level (BGL), then highly weathered granites up to 3.4 to 9.5 m BGL and then fresh granite until termination depth. Water was encountered in two of the bore holes in this area.
- TSF1: Test pits and hand auger investigations found superficial soils occupied the subsurface layers, and granite layers were encountered at depths of 0.45 to 1.7 m BGL.
- TSF 2 and 3: Test pits and hand auger investigations found superficial soils occupied the subsurface layers, and granite layers were encountered at depths of 0.4 to 1.9 m BGL.
- Evaporation pond: Test pits and hand auger investigations found superficial soils occupied the subsurface layers, and granite layers were encountered at depths of approximately 0.4 m BGL.

No groundwater was encountered over TSFs or evaporation pond areas.

Falling head *in-situ* permeability tests between 0.0 m and 11.9 m indicated relatively low permeability in the superficial soils and weathered rock (1.44×10^{-6} m/s to 7.91×10^{-8} m/s). *In-situ* permeability of between 3.73×10^{-6} m/s and 6.38×10^{-9} m/s were obtained from down borehole packer tests, performed in moderately to freshly weathered granite bedrock underlying the site. Despite relatively low permeability outcomes, ATC Williams (2017) recommend a proof compacting 300 mm of the in-situ clay layers creating a barrier to further reduce the likelihood of seepage. Vertical seepage rates will be very slow and it is unlikely that a hydraulic connection and fully saturated conditions between the decant water pond and groundwater will be established. There is potential for lateral seepage if engineering design controls are not implemented.

Potential operational leaks and spills will likely be minor although there may be a cumulative impact on surrounding lands and soils.

Surface water contamination may occur around the processing plant, evaporation pond or TSFs if not mitigated (discussed in section 6.3). This in turn will dilute contaminants and transport contaminants to downstream areas causing impact to the lands and soils.

Surface and subsurface waste rock characterisation identified materials that were highly erosive. The fresh waste rock and transitional rock components of the pits' lithology have a higher proportion of gravels, cobbles and larger clasts and will therefore provide more suitable armouring and growth media layers. If waste rock material is not characterised during mining and if the subsurface soils are used on the WRL surfaces then the integrity of the surface structure will be compromised and likely to erode.

5.4.6 Mitigation

Hastings commits to the following mitigation of potential impacts:

Best Practice

- Design, construction and operation of TSFs in accordance with policy and guidelines (listed in section 5.4.2).

Avoidance

- On-going characterisation and management of waste rock to ensure erosive materials are not used on surface slopes of waste rock landforms.
- Avoid using plains topsoils as a growth medium for rehabilitation of disturbed areas.
- Location of processing plant, evaporation pond and TSFs outside of the flood plain.

Minimisation

- Minimise dust generation using water sprays, where possible.
- Minimise potential for spills through personnel training and awareness.

Management

- Surface water management structures will be designed and constructed to minimise erosion.
- Diversion drains will be constructed to ensure water re-enters natural drainage lines at a velocity and depth that can be accommodated by the natural stream line without increased scouring.
- Contractor management, including:
    - Environmental compliance requirements in contracts.
    - Environmental Specification for Contractors (to be developed) will include:
        - requirement for site-specific and activity-specific EMP,
        - roles and responsibilities,
        - provision of Hastings relevant management plans, procedures, licence conditions,
        - provision of Hastings environmental policy,
        - ensuring each contractor has adequate resourcing for environmental management of their activities relative to the level of risk,
        - requirement for activity based and task specific environmental risk assessment, and
        - environmental performance reporting requirements.
    - Coordination of waste segregation, recycling and management.
    - Training and awareness.
    - Audits and inspections.
- Radiation Waste Management Plan (Appendix 5-7).
- Land Management Plan (to be developed) will include the following considerations:
    - Application of waste management hierarchy.

  - Containment bunding, silt and oil traps will be established where necessary to remove sediments or pollutants from runoff before water enters local drainage.
  - Spill clean-up procedures.
  - Visual monitoring will be undertaken of diversion channels and downstream drainage lines, and the condition of vegetation in the diversion channels.
  - Reference to water quality monitoring in a Water Management Plan (to be developed).
  - Visual monitoring of dust generation.
  - Contingency measures for excessive dust generation.
  - Waste management for general domestic and office waste, industrial waste, landfill, hydrocarbons, tyres, and sewage.
  - Management measures for dangerous and hazardous substances.
  - Hazard and incident reporting.
  - Pastoral activities and associated protocols.
  - Reference to procedures in the Cultural Heritage Management Plan (in draft).
- Waste Rock Management Plan (to be developed) will include the following considerations:
  - waste rock characterisation and segregation program during operations,
  - use of saprolites, pegmatites and other clay rich lithologies for TSF embankment lifts and low infiltration covers,
  - WRL batters to consist only of benign, competent durable fresh waste rock,
  - use of concave slopes on WRLs to reduce potential for erosion, and
  - waste rock with elevated radionuclide levels is to be distributed/diluted with waste rock containing low radionuclide levels in the WRL.

REHABILITATION

- Rehabilitation of waste facilities as per the Preliminary Mine Closure Plan (Appendix 6).

5.4.7 Predicted outcome

TSF 2 and 3 will likely be listed as contaminated sites under the *Contaminated Sites Act 2003* (WA) due to the storage and containment of tailings with elevated radionuclides. This represents an area of approximately 20 Ha.

The potential impacts will be mitigated as described in section 4.4.6 so that the Proposal meets the EPA objective:

To maintain the quality of land and soils so that environmental values are protected.

5.5 KEY ENVIRONMENTAL FACTOR 4: INLAND WATERS ENVIRONMENTAL QUALITY

5.5.1 EPA objective

To maintain the quality of groundwater and surface water so that environmental values are protected.

5.5.2 Policy and guidance

Laws and regulations relevant to the consideration of inland waters environmental quality include:

Environment Protection and Biodiversity Conservation Act 1999 (Commonwealth)

Mining Act 1950 (WA)

Rights in Water and Irrigation Act 1914 (WA)

Waterways Conservation Act 1976 (WA)

Waterways Conservation Regulations 1981 (WA)

Relevant guidelines include:

ANZECC and ARMCANZ (2000) Australian and New Zealand guidelines for fresh and marine water quality;

DMP and EPA (2015) Guidelines for Preparing Preliminary Mine Closure Plans;

DoW (2009a). Hydrogeological reporting associated with a groundwater well licence;

DoW (2009b) Water quality monitoring program design: A guideline for field sampling for surface water quality monitoring programs;

DoW (2011) Use of operating strategies in the water licencing process;

DoW (2013a) Western Australian Water in Mining Guideline;

DoW (2013b) Use of mine dewatering surplus;

DoH (2013) System compliance and routine reporting requirements for small community water providers;

EPA (2003) Guidance Statement 55 - Implementing best practice in proposals submitted to the environment impact assessment process;

EPA (2004d) Position Statement No. 4: Environmental protection of wetlands;

EPA (2016h) Environmental Factor Guideline: Inland waters environmental quality;

Johnson and Wright (2003) Mine void water resource issues in Western Australia, Hydrogeological Record Series HG9;

NHMRC and ARMCANZ (1996). Australian drinking water guidelines; and

WRC (2000) Water Protection Guidelines No. 11 Mining and Mineral Processing: Mine dewatering.

5.5.3 Receiving environment

The following studies have informed this section:

- Soils Assessment Report (Landloch 2016; Appendix 5-2)

- Conceptual Hydrogeological Assessment (Global Groundwater 2016; Appendix 4-1)
- Hydrogeological Assessment (GRM 2017; Appendix 4-2)
- Surface Water Assessment Report (JDA 2016; Appendix 4-3)
- Geotechnical Assessment (ATC Williams 2017; Appendix 5-9)

The Proposal is located within the Gascoyne River catchment, which occurs within the Gascoyne Surface Water Proclamation Area and the Gascoyne Groundwater Proclamation Area. There are no wetlands of international importance within the development envelope or in close proximity to the proposal.

Two tributaries of the Lyons River, Yangibana Creek and Fraser's Creek, occur within or in the near vicinity of the proposed development envelope. Both creeks are ephemeral and only flow following rainfall although semi-permanent pools occur along their lengths. Two semi-permanent pools occur within 5-10 km of the Proposal. Water quality sampling has been undertaken to provide baseline information for the Proposal.

The environmental values of surface flows in the Proposal area are riparian vegetation, ephemeral pools with associated groundwater dependent ecosystems (GDEs) and the network of shallow calcrete aquifers associated with the Gifford Creek PEC.

The water requirements for the Proposal are approximately 2.5 GL/annum. Water will be sourced from pit dewatering activities supplemented by groundwater bores. Pit dewatering will occur from fractured rock aquifers. Groundwater samples were collected from each of the production bores at the end of the test pumping. Water quality analyses of the samples indicates a pH range of 7.8 to 8.5 and a salinity range of 920 to 1,200 mg/L total dissolved solids (TDS;

Table **9**). Total dissolved thorium values of samples taken within the proposed deposit areas were <0.001 mg/L and total dissolved uranium ranged from 0.014 to 0.016 mg/L.

Pastoral stations are the only other groundwater users in the vicinity of the Proposal, with water used for domestic and stock purposes. The nearest pastoral bore is approximately 2 km from the Proposal. None of the existing pastoral bores are located within the fractured ironstone aquifers associated with the pit dewatering and groundwater abstraction activities of the Proposal. Water quality parameters from eight pastoral station bores were variable depending on location. pH ranged from 7.2 to 8.6 and salinity ranged from 600 to 2,800 mg/L TDS (**Table 9**). Total dissolved thorium values were <0.001 mg/L whereas total dissolved uranium ranged from 0.004 to 0.079 mg/L.

Water quality analysis was also conducted at two ephemeral pools (LC - Pool 800US and FR – Pool) on the Lyons River, located approximately 5-10 km from the Proposed processing plant. These samples were collected at the end of the dry season and thus parameters measured (**Table 9**) will vary depending on time since last rainfall.

A range of water quality parameters have been tested and can be found in the appendices of RadPro 2016a; Appendix 5-4).

Table 9 Summary of water quality analysis

Water Quality Parameters	Water within pits	Pastoral bores	Ephemeral pools
pH range	7.8 – 8.5	7.2 – 8.6	8.1 - 9.6
Salinity range (mg/L)	920 - 1200	600 - 2800	330 - 1200
Total dissolved Th (mg/L)	<0.001	<0.001	<0.001
Total dissolved U (mg/L)	0.014 – 0.016	0.004 – 0.079	0.001 – 0.004

5.5.4 Potential impacts

Potential impacts include:

- Increased sediment load to streams from the presence of the Proposal.
- Surface water contamination from processing reagents, chemicals and hydrocarbons.
- Surface water / groundwater contamination from process liquor in the decant pond and evaporation pond.
- Biological contamination to surface water / groundwater from the sewage treatment plant(s).
- Groundwater contamination from landfill leachate, tailings seepage, and drainage from waste rock landforms.
- Final void pit lakes are likely to increase in salinity over time.

5.5.5 Assessment of impacts

Design and location of infrastructure are unlikely to result in additional sediment loads during heavy rainfall events. A soils assessment report (Appendix 5-2) has highlighted plains topsoils are unsuitable for use in rehabilitation due to their saline and sodic nature, and are highly erodible. These soils will not be harvested or stored.

Bunding and secondary bunding around chemical storage areas is standard practice. In addition, surface water will be contained in areas around the processing plant and tailings storage facilities, where runoff may become contaminated. Therefore it is unlikely that any major surface water contamination will occur as a result of chemical storage.

The decant pond and evaporation pond will be designed with sufficient freeboard to ensure water is contained during heavy rainfall events. It is unlikely that contaminated water will be discharged from these facilities.

Discharge or leakage of water from sewage treatment plant(s) is unlikely. The construction and operations of prescribed facilities has strict regulatory controls under part V of the *Environmental Protection Act 1987* (administered by the Department of Environment Regulation (DER)). This also applies to other prescribed facilities such as the landfill and processing plant (and associated tailings storage facilities).

Seepage from the tailings storage facilities is unlikely with the implementation of standard management and regulatory practices, and best practice design, construction and operations.

5.5.6 Mitigation

Hastings commits to the following mitigation of potential impacts:

Best Practice

- Design and construct all hazardous materials storage areas to meet Australian Standards, including impermeable bunding, as required.
- Design, construct and operate the landfill and waste water treatment plant to meet relevant statutory requirements.
- Design and construct TSFs, decant pond and evaporation pond in accordance with international best practice to minimise risks of seepage and mass failure during operations or post-closure.

Avoidance

- Exclusion of disturbance within 150 metres of Yangibana and Fraser Creeks, with the exception of road crossings.
- Locate soil stockpiles away from drainage lines and flood zones.
- Design the Proposal layout so that mining landforms are located outside the Yangibana and Fraser Creeks flood zones.
- Exclusion of groundwater abstraction from calcrete aquifers.

Minimisation

- Design and locate infrastructure to minimise potential impacts associated with flood events.

Management

- Design and construct surface water management structures to:
    - divert overland flows around mining landforms to minimise erosion and sedimentation,
    - ensure linear infrastructure does not result in erosion and sedimentation,
    - protect the processing plant, evaporation pond and tailings storage facilities from surface water flows during heavy rainfall events, and
    - manage contaminated surface water runoff within processing plant, evaporation pond and TSF areas.
- Radiation Waste Management Plan (RWMP; Appendix 5-7).
- Groundwater Operating Strategy (to be developed for 5C licence).
- TSF Operating Manual including:
    - short and long term range of readings that are anticipated for all monitoring instruments, monitoring bores, underdrain flows, and open channel flows, throughout the life of the TSF, and
    - actions to be followed in the event that readings are recorded outside an anticipated envelope of measurements should be stipulated in the TSF Operating Manual.
- Drinking Water Quality Management Plan (to be developed).

- Water Management Plan (to be developed) to summarise and describe inter-relationships of water quality management and monitoring actions determined by the:
  - RWMP,
  - Groundwater Operating Strategy,
  - TSF Operating Manual,
  - Drinking Water Quality Management Plan, and

  and ensure any gaps not covered in the above plans are addressed.

REHABILITATE

- Natural surface drainage to be considered post-closure, and
- Bunding to prevent erosion of landforms post-closure.

5.5.7 Predicted outcome

The above mitigation will ensure potential impacts are unlikely to occur thus satisfying the EPA objective:

To maintain the quality of groundwater and surface water so that environmental values are protected.

5.6 Key environmental factor 5: Human health

5.6.1 EPA objective

To protect human health from significant harm.

5.6.2 Policy and guidance

Laws and regulations relevant to the consideration of human health include:

Environment Protection and Biodiversity Conservation Act 1999 (Commonwealth)

Mines Safety and Inspection Act 1994 (WA)

Occupational Safety and Health Act 1984 (WA)

Radiation Safety Act 1975 (WA)

Relevant guidelines include:

ARPANSA (2005) Code of practice & safety guide: Radiation protection and radioactive waste management in mining and mineral processing; known as “the Mining Code”;

ARPANSA (2008) Safety guide: Management of naturally occurring radioactive material;

ARPANSA (2014a) Fundamentals: Protection against ionising radiation;

ARPANSA (2014b) The code: Safe transport of radioactive material;

DMP (2010) Managing naturally occurring radioactive material (NORM) in mining and mineral processing - guideline (2nd edition);

EPA (2016f) Environmental Factor Guideline: Human health;

IAEA (2003) Radiation protection against radon in workplaces other than mines;

IAEA (2006) Assessing the need for radiation protection measures in work involving minerals and raw materials;

IAEA (2010) Handbook of parameter values for the prediction of radionuclide transfer in terrestrial and freshwater environments; and

ICRP (2014) Protection of the environment under different exposure situations.

5.6.3 Receiving environment

The following studies have informed this section:

- Baseline Radiation Report (RadPro 2016a; Appendix 5-4)
- Radiation Waste Characterisation Report (RadPro 2016b; Appendix 5-5)
- Radiation Impact Assessment (JRHC Enterprises 2016; Appendix 5-6)
- Air Quality Assessment and Memo (Pacific Environment 2016a and b; Appendix 7-1 and 7-2)

CHARACTERISATION

The uranium and thorium content of the ore and various processing streams are shown in **Table 10**.

Table 10 Uranium (U) and thorium (Th) content of materials

Material	Unit	U	Th	Comment
Ore	ppm	27	450	Est. to be in secular equilibrium
Waste Rock	ppm	10	71	Est. to be in secular equilibrium
Beneficiation Tailings (TSF1)	ppm	23	147	Est. to be in secular equilibrium
Re-flotation Tailings (TSF2)	ppm	45	1,922	Est. to be in secular equilibrium
TREO Concentrate	ppm	171	9,298	Est. to be in secular equilibrium
Hydromet Residue (TSF3)	ppm	94	5,092	Considered to be out of equilibrium
Liquid Residue from Hydromet	mg/L	0.19	0.003	Considered to be out of equilibrium
Rare Earth Product	ppm	<80	6	Considered to be out of equilibrium

SENSITIVE RECEPTORS

Sensitive receptors are considered to be 1) workers, and 2) members of the public.

Doses to the workforce, including occupational doses to the following workgroups:

- mine workers,
- processing plant workers, and
- other workers.

Doses to members of the public occur when emissions from inside the operation impact upon people outside the operation. This is quantified by identifying a representative person at locations of interest and then determining the potential dose to that person from the project emissions. For impacts to non-human biota, it is common to use the same locations.

In this assessment, the locations of interest are:

- accommodation village (approximately 5 km from the main project area),
- Gifford Creek Station homestead (approximately 10 km to the south of the main project area), and
- Edmund Station homestead (approximately 20 km north of the main project area).

The assessment assumes that a member of the public resides at the locations of interest for a full year at the Edmund and Gifford Creek Station homestead locations, and 4,000 hours per year for the accommodation village location.

GAMMA

Gamma exposure estimates are based on the work of Thompson and Wilson (1980) who derived a gamma dose rate factor for natural *in situ* uranium of 65µSv/h per %U for a 2π exposure situation (i.e. equivalent to standing on an infinite plane source or exposure from one side only). For thorium in ore, the IAEA provide a factor of 16µSv/h per %Th for 2π exposure (IAEA 2006).

Based on these factors, dose rates for the various materials were calculated (**Table 11**).

Table 11 Gamma dose rate for various materials

Material	Concentrations (ppm)		Total Dose Rate (μSv/h)
	Uranium	Thorium	
Ore	27	450	0.9
Waste Rock	10	71	0.2
Beneficiation Tailings (TSF1)	23	147	0.4
Refloat Tailings (TSF2)	45	1,922	3.4
TREO Concentrate	171	9,298	16
Hydromet Residue (TSF3)	94	5,092	8.8
Final Product	<80	6	0.5

RADON AND THORON EMISSIONS

A summary of the radon emission rates is shown in **Table 12**.

Table 12 Estimated radon and thoron releases

Source	Radon (MBq/s)	Thoron[1] (MBq/s)
Mine	0.8	40
Beneficiation Plant	0.1	0.1
Beneficiation Tailing	0.1	25
Processing Plant	0.1	175
Process Residues	Minor	Minor
Stockpiles	0.9	60
Total	2	300

DUST EMISSIONS

It has been assumed that all of emissions are mineralised dust, which has an average uranium concentration of 27ppm and average thorium concentration of 450 ppm. In practice, a significant proportion of the emitted dust will be non-mineralised.

At these concentrations, there will be approximately 0.3 Bq/g of each radionuclide in the uranium decay chain (U238) and 2 Bq/g of each long lived radionuclide in the thorium decay chain.

5.6.4 Potential impacts

The potential impact of exposure to humans occurs via four main exposure pathways:

- Gamma irradiation.
- Inhalation of radon decay products (RnDP) and thoron decay products (TnDP).
- Inhalation of radionuclides in dust.
- Ingestion of animals or plants that have come in contact with emissions.

5.6.5 Assessment of impacts

The information for this section has been obtained directly from the Radiation Impact Assessment (JRHC 2016; Appendix 5-6).

In Publication 26 (ICRP 1977), the ICRP first recommended the 'system of dose limitation', which has become the internationally accepted approach to emissions protection and is universally adopted as the basis of legislative systems for the control of radiation. It is made up of three key elements as follows:

- Justification – this means that a practice involving exposure should only be adopted if the benefits of the practice outweigh the risks associated with the exposure.
- Optimisation – this means that the doses and potential costs should be balanced so that doses are As Low As Reasonably Achievable (ALARA), taking into account economic and social factors. This is also known as the ALARA principle.
- Limitation – this means that individuals should not receive doses greater than the prescribed dose limits.

Within the 'system of dose limitation', the ALARA principle is generally regarded as the most important and the most effective of these elements for the control and management of radiation. In the design stage of a project, ALARA means identifying hazards and making design, engineering and infrastructure decisions to ensure that potential doses are as low as reasonably achievable. In operation, ALARA is similar to continuous improvement, where ongoing efforts are made to ensure that practices, procedures and systems are monitored and reviewed.

While the ALARA principle is the foundation for radiation protection, prescribed dose limits have been established to provide an absolute level of protection. The limits apply only to the dose received as a result of a 'practice', and excludes natural background emissions levels. The limits are:

- 20 mSv/y for a worker (whilst at work), and
- 1 mSv/y for a member of the public (total year).

The Radiation Impact Assessment (JRHC 2016; Appendix 5-6) has shown that the radiological impacts from the proposed project to workers would be low. Conservative estimates show that doses to all workers would be less than 5 mSv/y, compared to the annual limit of 20 mSv/y.

The impact assessment has also shown that the radiological impacts from the proposal to members of the public are negligible, with values estimated to be less than 0.01 mSv/y, well below the limit of 1 mSv/y.

<u>WORKFORCE</u>

[1] Note that the relatively higher figure for thoron is due to its very short half-life. Once thoron is produced, it almost immediately decays, therefore, the activity is high. Whereas, for radon, the longer half-life means that there is a lower activity for a similar number of atoms of radon (JRHC 2016; Appendix 5-6).

1. MINE WORKERS

Gamma exposure estimates were calculated and are shown in **Table 11**.

Mine worker exposures assumes that large mining equipment offers, on average, a 50% reduction in gamma exposure. In practice, for a 2π exposure geometry, the actual attenuation is higher due to the equipment shielding most of the gamma from below.

Based on exposure to ore for 2,000 hours per year, the predicted mine worker gamma doses are:

- Annual Dose = 0.9µSv/h x 2,000h/y x 0.5 = 0.9mSv/y

A modified box model has been used to estimate radon and thoron doses to mine workers.

The model considers:

- the amount of radon (Rn^{222}) and thoron (Rn^{220}) entering the mine void,
- the ventilation rate of the mine void, (which is the time it takes for air to turn over in the mine) and is based on the average natural wind speed,
- the calculation of a steady state (equilibrium) concentration of radon and thoron in the mine,
- determination of the decay product concentrations from the radon and thoron gas concentrations using established equilibrium factors, and
- calculation of worker doses based on exposure time and decay product concentrations.

Emission estimates used for the air quality modelling indicate that approximately 0.13 MBq/s of radon and 8 MBq/s of thoron will be emitted from the operating mine pits.

For the assessment, the following assumptions have been made:

- since Frasers is the largest deposit, with almost 50% of the material mined, it is assumed that half the estimated release of radon and thoron is emitted from this one mine pit (conservative approach as it assumes all ore is economically extractable),
- the dimensions of the modelled pit are: length is 600 m, width is 600 m and maximum possible depth is 150 m,
- the pit volume is 13 Mm^3, and
- the average wind speed in the region is approximately 4 m/s (Pacific Environment 2016).

The ventilation rate of the one mine pit is calculated using the following formula:

- $T = 33.8 \times (V/U_rLW) \times (0.7\cos(\theta) + 0.3)$, where:
  - T is the residence time of air in the pit,
  - U_r is the wind velocity in metres per hour,
  - L is the length of the pit, and
  - W is the width of the pit.

The term '(0.7cos(θ) + 0.3)' is used to take into account the shape of the pit, however, for simplicity, the pit has been approximated to a square, therefore the term equates to 1.

The average wind speed for the region is 4 m/s, which is equivalent to 14,400 m/h. Using the formula and the assumptions, the calculated air residence time is 0.08 hours. This is the same as saying that at the average wind speed, the air in the pit would turn over approximately 12 times per hour.

The radon equilibrium concentration is calculated using the following equation:

- Radon concentration (Bq/m^3) = ER/(PV x VR) where,
    - ER is the radon (or thoron) generation rate in the pit (in Bq/h),
    - PV is the pit volume, and
    - VR is the number of air changes per hours.

Using the figures above, the equilibrium concentrations are as follows:

- Radon (Rn^{222}) is 2 Bq/m^3, and
- Thoron (Rn^{220}) is 46 Bq/m^3.

These figures are above the naturally occurring levels that exist in the region, and are a result of the proposed operations. The concentrations are low because the emission rate is relatively low and the ventilation rate is high.

The equivalent decay product concentrations are calculated using the following relationships:

- RnDP (mJ/m^3) = $5.56 \times 10^{-6} \times E_{Rn} \times$ Radon conc. (Bq/m^3)
- TnDP (mJ/m^3) = $7.57 \times 10^{-5} \times E_{Tn} \times$ Thoron conc. (Bq/m^3)
- where:
    - RnDP and TnDP are the potential alpha energy exposures to radon progeny and thoron decay products,
    - E_{Rn} is the equilibrium factor for radon progeny (0.4),
    - E_{Tn} is the equilibrium factor for thoron progeny (0.01),
    - C_{Rn} is the radon gas concentration (Bq/m^3), and
    - C_{Tn} is the thoron gas concentration (Bq/m^3).

The calculated concentrations are:

- RnDP – 0.004uJ/m^3, and
- TnDP – 0.035uJ/m^3.

The doses are calculated as follows:

- Dose (mSv/y) = RnDP Conc. (mJ/m^3) x Working hours (h/y) x dose factor (mSv.m^3/mJ.h)

This gives estimated doses from inhalation of RnDP and TnDP of 0.013 and 0.033 mSv/y, respectively, giving a total inhalation dose from decay products of radon and thoron of 0.046 mSv/y.

<u>Airborne dust exposures</u> can be determined by combining the activity concentration of the airborne dust with the exposure time. The activity concentration can be calculated from the dust mass concentration combined with the known radionuclide composition of the dust.

For this assessment, an average mine dust mass concentration of 3 mg/m^3 has been used.

The mineralised ore contains on average 27 ppm of uranium and 450 ppm of thorium and the average activity concentrations[2] are therefore 0.3 and 1.8 Bq/g, respectively.

Dust Dose (U) = 3 mg/m^3 x 0.3 mBq/mg x 1.2 m^3/h x 2,000 h/y x 7.2 uSv/αdps x 5 αdps/Bq

[2] The activities are based on specific activities of U238 and Th232 of 12,400 Bq/g and 4,060 Bq/g, respectively.

= 0.081 mSv/y

Dust Dose (Th) = 3 mg/m^3 x 0.3 mBq/mg x 1.2 m^3/h x 2,000 h/y x 11 uSv/αdps x 4 αdps/Bq

= 0.119 mSv/y

2. PROCESSING PLANT WORKERS

Gamma doses in the beneficiation plant and the hydrometallurgical plant are expected to be low and this is due to a number of key factors. These include:

- Once crushed and ground, the ore will be in a slurry form, therefore opportunities for dust generation will be absent.
- The slurries will be in process vessels and tanks in a diluted form (due to the slurry nature).
- Defacto shielding will be provided by the processing vessels and tanks.
- Processing facilities do not have permanent work locations, apart from control rooms. It is usual for plant operators to move all around the plant to undertake their duties.
- Identification of areas where levels are elevated and implementation of appropriate operating procedures.

Experience at uranium production operations, for example Ranger and Olympic Dam, shows that metallurgical plant workers generally receive gamma doses of approximately 1 mSv/y. The material in the processing facilities of the proposal will provide similar gamma levels to those experienced at other operations.

The main area where it is likely that there will be elevated gamma is in the handling of the mixed rare earth concentrate. The concentration of thorium decay chain radionuclides and the subsequent estimated gamma dose rates can be seen in **Table 11**. The material will contain elevated concentrations of thorium chain radionuclides, prior to their removal in the hydrometallurgical process and the surface dose rates in this area will depend on the total mass of material and the contained activity. The residence time will also be a factor, because decay products may grow into equilibrium with parent radionuclides.

An assessment of doses via the exposure pathways is difficult due to the uncertain exposure geometries. Therefore, for this assessment, it is assumed that the doses received by workers will be similar to doses received at an operation with similar processing methods and radioactivity levels. For this assessment, the actual doses from the Olympic Dam concentrator and hydrometallurgical plant have been used.

The assumptions used for the assessment are based on the average Olympic Dam doses from 2001 to 2007 (**Table 13**).

Table 13 Assumptions used in processing plant for workers dose estimates

Processing Plant Area	Assumptions
Beneficiation Plant	Use doses received by Olympic Dam concentrator plant workers and scaled
Hydrometallurgical Plant	Use doses received by Olympic Dam hydrometallurgical plant workers

Based on the assumptions, the dose estimates for the processing plant work areas were calculated (**Table 14**).

Table 14 Processing plant work area dose estimates

Processing Plant Work Area	Doses (mSv/y)			
	Gamma	Dust Inhalation	RnDP	Total
Beneficiation Plant	0.3	0.3	0.1	**0.7**
Hydrometallurgical Plant	0.8	0.7	0.3	**1.8**

3. OTHER WORKERS

Administration workers would mainly work in offices located adjacent to the processing plant. The work area would be outside of the main processing plant area and workers would not be required to undertake any special requirements for exposure control.

Exposures for administration workers would be as follows:

- Gamma – no close sources of gamma ore, therefore gamma dose expected to be negligible.
- Dust exposure – assume that a dust concentration of 0.5 mg/m^3 of ore dust is present in the workplace (note that this would be considered a relatively high concentration and require mitigation), the inhalation dose would be approximately dose 0.033 mSv/y.
- RnDP exposure – assumed to be negligible (based on miner doses).

MEMBERS OF THE PUBLIC

GAMMA

Gamma exposure to members of the public from sources within the project area is considered to be negligible due to the distance between the sources and the public. The sources of gamma (for example, ore stockpiles) are well within the proposal boundary and inaccessible by the public.

Gamma intensity reduces significantly with distance (as one divided by the distance squared when the source is at a distance to be considered to be a point source). The gamma levels at the closest accessible area would be barely detectable, of the order of nSv/h.

RADON AND THORON

The modelled annual average ground level concentrations during operations at each of the locations of interest can be seen in **Table 15**. It should be noted that the baseline monitoring (RadPro 2016a; Appendix 5-4) gives an average naturally occurring radon and thoron concentration of approximately 10 Bq/m^3 and 20 Bq/m^3 respectively (using long term passive detectors).

Table 15 Annual average modelled radon ground level concentrations

Location	Incremental Ground Level Radon Concentrations Annual Average (Bq/m^3)	Incremental Ground Level Thoron Concentrations Annual Average (Bq/m^3)
Accommodation Village	0.003	<0.001
Gifford Creek Station	0.001	<0.001
Edmund Station	0.002	<0.001

AIRBORNE DUST EMISSIONS

The dust concentration is multiplied by the specific activity of the dust to give an activity concentration and these are also shown in **Table 16**.

Table 16 Annual ground level concentrations

Location	Ground Level Concentrations Dust (µg/m^3)	Equivalent Uranium Chain Radionuclide Concentration (µBq/m^3)	Equivalent Thorium Chain Radionuclide Concentration (µBq/m^3)
Accommodation Village	0.30	0.09	0.60
Gifford Station	0.16	0.05	0.32
Edmund Station	0.40	0.12	0.80

DUST DEPOSITION

The deposition rate of dust into the environment was modelled and the total dust and radionuclide deposition into the environment at the sensitive receptors has been calculated for the life of the project (7 years).

The results are used to provide an estimate of human doses from ingestion of food that has taken up radionuclides. The results are also used for determining project originated soil radionuclide concentration estimates of impacts to non-human biota. Results from the modelling are shown in **Table 17**.

Table 17 Dust deposition

Location	Cumulative Dust Deposition (7 years) (g/m^2)	Uranium Chain Radionuclide (Bq/m^2)	Thorium Chain Radionuclide (Bq/m^2)
Accommodation Village	1.18	0.40	2.21
Gifford Station	0.17	0.06	0.32
Edmund Station	0.59	0.20	1.10

INGESTION DOSE ESTIMATES

The intake of radionuclides is a function of the 1) quantity of radionuclides in the soil, 2) quantity of radionuclides that transfer to food and 3) food intake rate.

1) Quantity of radionuclides in the soil

The calculated change in soil radionuclide concentrations at each location of interest is based on the air quality deposition modelling. **Table 18** shows the calculated change in soil concentration based on soil density of 2 t/m^3 and a mixing depth of 10 mm. It is assumed that the uranium and thorium decay chain is in secular equilibrium, therefore the radionuclide concentration applies to each of the radionuclides in the uranium decay chain.

Table 18 Change in soil radionuclide concentration (after 7 years of operations)

Location	Radionuclide Deposition (Bq/m^2)*1		Change in Soil Concentration (Bq/kg)*2	
	Uranium Series	Thorium Series	Uranium Series	Thorium Series
Accommodation Village	0.40	2.21	0.020	0.110
Gifford Creek Station	0.06	0.32	0.003	0.016
Edmund Station	0.20	1.10	0.010	0.055

Note 1: From Table 11.

Note 2: Calculated as Soil concentration (Bq/kg) = Deposition (Bq/m^2) / (Mixing Depth (m) x Soil Density (kg/m^3))

2) Quantity of radionuclides that transfer to food

The concentration ratio is a factor that relates the concentration of an element in the media (such as soil and foods) and the concentration of the element in the plant or animal. For plants, it is the ratio between the soils and the plant. For animals, it is the ratio between the food and the animals.

Published factors are available in IAEA (2010) and Strenge et al. (2003). For this assessment, the uptake factors used are shown in **Table 19**.

Table 19 Uptake factors

	Vegetation[1] Bq/kg (dry weight)/Bq/kg (dry soil weight)			Kangaroo[2] Bq/kg (whole body) per Bq/d (ingested)
	Non Leafy	Leafy	Root	Whole Body
Uranium	0.053	0.020	0.028	0.007
Thorium	0.0022	0.0012	0.0087	0.00016
Radium	0.061	0.091	0.071	0.41
Polonium	0.00019	0.0074	0.077	0.55
Lead	0.015	0.080	0.063	0.022

Note 1: The concentration ratio figures are quoted as 'dry weight'. To apply the ratios to live plant matter, a factor needs to be applied which converts the dry weight to a wet weight. For this assessment it has been conservatively assumed that the wet weight is twice the dry weigh. In reality the wet weight may be 4 or 5 times higher and depends upon the plant species, so the figure used is conservative.

Note 2: Concentration ratios are from ARPANSA 2014c and are provided for assessment of dose from intake of kangaroo meat.

3) Food intake rate

The assessment is based on the following consumption rates from http://www.goodfood.com.au/:

- Vegetation
  - 40 kg/y of non-leafy vegetables
  - 10 kg/y of leafy vegetables
  - 70 kg/y of root vegetables
- 110 kg/y of meat (assumed to be kangaroo from the local area).

For example, to calculate the dose from project originated U^{238} from ingestion of leafy vegetables at the closest eastern boundary, the calculations are as follows:

- Data:
  - Assumed ingestion of leafy vegetables is 10 kg/y
  - The projects originated soil uranium 238 concentration is 0.020 Bq/kg
  - The concentration ratio for uranium for leafy vegetables is 0.02 Bq/kg (dry eight) per Bq/kg (soil) (converting to wet weight gives 0.01 Bq/kg(wet weight) per Bq/kg (soil))
- Calculation of plant uptake:
  - Plant uranium concentration is 0.01 x 0.020, giving 0.002 Bq/kg
- Calculation of intake:
  - Assume consumption of 10 kg per year, giving an intake of uranium 238 of 0.02 Bq

This calculation method is then applied to each radionuclide for the different food types and consumption rates and added together to give the total intake for each radionuclide (**Table 20**).

Table 20 Data for ingestion dose assessment

	Dose (mSv/y)			
Location	**Vegetation Ingestion**	**Kangaroo Ingestion**	**Total Ingestion**	**Meat[1] Ingestion**
Accommodation Village	0.0004	0.005	0.005	<0.0001
Gifford Station	0.0001	0.001	0.001	<0.0001
Edmund Station	0.0002	0.003	0.003	<0.0001

Note 1: Standard meat (beef) consumption doses provided for comparison purposes.

TOTAL DOSE FOR EACH EXPOSURE PATHWAY

The total dose estimates at the sensitive receptors (**Table 21**) are based on 100% occupancy (that is 8,760 hours per year) for the station homestead locations and 4,000 hours per year for the accommodation village.

Table 21 Public total dose estimates

Location	Exposure Pathway Dose (mSv/y)					
	Gamma	**Dust**	**ThDP**	**RnDP***	**Ingestion**	**Total Dose**
Accommodation Village	0.000	0.000	0.000	0.001 (0.002)	0.005	0.006 (0.007)
Gifford Station	0.000	0.000	0.000	<0.001 (0.001)	0.001	0.002 (0.002)
Edmund Station	0.000	0.000	0.000	0.001 (0.002)	0.003	0.004 (0.006)

* The figures in parenthesis represent the calculated dose based on the new ICRP dose factor for radon decay products.

5.6.6 Mitigation

Hastings commits to the following mitigation of potential impacts:

BEST PRACTICE

- Thorough understanding of baseline radionuclide levels.

AVOIDANCE

- Processing extracts radionuclides to levels in product not considered ‘radioactive’ thus avoiding risk along the transport route.
- Location of infrastructure to avoid impacts to sensitive receptors

MINIMISATION

- Maintain a wet process and TSF 2 and 3 maintained as 'wet' to minimise dust emissions.
- Design of processing plant and TSF 2 and 3 to minimise the potential to impact sensitive receptors from dust emissions.
- Design of the processing plant to minimise exposure to gamma radiation.

MANAGEMENT

- The Radiation Management Plan (Appendix 5-8) is the primary document for the management and monitoring of potential impacts to human health and safety and will form a component of the Safety Management System.
- The Radiation Waste Management Plan (Appendix 5-7) is the primary document for the management and monitoring of potential impacts to the surrounding environment and will form a component of the Environmental Management System.

REHABILITATION

- Preliminary Mine Closure Plan (Appendix 6).

5.6.7 Predicted outcome

Taking into account the 'system of dose limitation', the predicted outcomes are discussed in context of the three key elements as follows:

- Justification – naturally occurring radionuclides are associated with the target rare earths ore body. During processing they become concentrated in two of the three tailings streams. It is not possible to avoid mining and concentrating the radionuclides. The economic and environmental benefits outweigh the risks associated with the exposure.
- Optimisation – exposure to doses are reduced to As Low As Reasonably Achievable (ALARA), by maintaining a 'wet' processing plant and 'wet' tailings in TSF 2 and 3 to reduce potential dust generation. Other design features also consider reducing doses to ALARA as described in the RMP and RWMP. Encapsulation of the tailings waste and capping of TSF 2 and 3 at closure will also ensure doses are reduced to ALARA and are representative of the background gamma levels. A TSF operating manual will also ensure the TSFs are constructed in accordance with design specifications and will describe monitoring of the integrity of each TSF structure to be conducted during the operations phase.
- Limitation – the impact assessment determined that doses will not exceed the prescribed dose limits for the workforce or members of the public. Monitoring during operations will confirm and verify this information. A precautionary approach will be maintained commensurate with the level of risk.

As a result of the application of the 'system of dose limitation', the EPAs objective will be achieved:

To protect human health from significant harm.

6 OTHER ENVIRONMENTAL FACTORS OR MATTERS

The following environmental factors are considered as 'other environmental factors':

- Landforms: The proposal sits within a flat landscape with no unique features/habitat.
- Terrestrial fauna: Conservation significant fauna and habitat occur outside of proposal.
- Hydrological processes: Minimal water demands of 2.5 GL/annum.
- Air quality: Minimal greenhouse gas emissions and generation of dust is primarily by vehicle movements, which can be managed by standard procedures.
- Social: Heritage, noise, dust and visual amenity have been considered under this environmental factor and there are either no impacts to the surrounding environment or they can be easily mitigated.

The same approach as that used to assess key environmental factors in section 5 has been applied to these factors.

6.1 LANDFORMS

6.1.1 EPA objective

To maintain the variety and integrity of distinctive physical landforms so that environmental values are protected.

6.1.2 Policy and guidance

Laws and regulations relevant to the consideration of landforms include:

Environmental Protection Act 1978 (WA)

Relevant guidelines include:

EPA (2016i) Environmental Factor Guideline: Landforms

6.1.3 Receiving environment

he following study has informed this section:

- Visual Amenity Impact Assessment (Ecoscape 2016; Appendix 8-1)

The bulk of the Proposal area is characterised by subdued topography with broad open flats and occasional rounded granitic hills, with elevations to about 350 m AHD (Australian Height Datum). The drainage lines in the area of the granitic rocks form a dendritic pattern and are located within generally broader more gently sloping areas of alluvial deposition.

The Proposal area does not represent:

- a distinctive physical landform;
- banded iron formations;
- dunes and dune fields; or
- caves and cave systems.

The closest distinctive physical landform is Mount Augusta, located approximately 80 km southeast of the Proposal.

6.1.4 Potential impacts

Potential impacts include:

- A localised change in topography as a result of waste rock landforms (up to 40 m high).

6.1.5 Assessment of impacts

There is a trade-off in ensuring 1) safe, stable, non-polluting landforms that meet closure criteria (discussed in section 5.4), 2) reducing impacts from disturbance (discussed in section 5.2), and 3) maintaining a similar topography post-closure.

The height of the WRL is determined by physical characterisation of the waste rock. Waste characterisation (i.e. physical and chemical characterisation) informs the engineering design, which aims to also meet closure criteria. It is widely acknowledged that avoidance of impacts to flora and vegetation should be implemented, where possible, during the planning phase of the proposal. For example, a WRL that is 40 m tall will disturb less vegetation than one which is 5 m tall and has a larger overall footprint. However, the 5 m tall waste rock landform will more likely mimic the local landforms present prior to implementation of the proposal.

Given that the visual amenity of the proposal is low (discussed further in section 6.5), considerations of disturbance to flora and vegetation, and terrestrial environmental quality will take preference over the impact of landforms.

6.1.6 Mitigation

No mitigation required.

6.1.7 Predicted outcome

The Proposal will meet the EPA's objective for this environmental factor:

To maintain the variety and integrity of distinctive physical landforms so that environmental values are protected.

6.2 TERRESTRIAL FAUNA

6.2.1 EPA objective

To protect terrestrial fauna so that biological diversity and ecological integrity are maintained.

6.2.2 Policy and guidance

Laws and regulations relevant to the consideration of terrestrial fauna include:

Environment Protection and Biodiversity Conservation Act 1999 (Commonwealth)

Environmental Protection Act 1978 (WA)

Wildlife Conservation Act 1950 (WA)

Relevant guidelines include:

DEWHA (2009) Matters of National Environmental Significance. Significant impact guidelines 1.1 - *Environment Protection and Biodiversity Conservation Act 1999*;

EPA (2002) Position Statement No. 3: Terrestrial biological surveys as an element of biodiversity protection;

EPA (2004) Guidance Statement No. 56: Terrestrial fauna surveys for environmental impact assessment in Western Australia;

EPA (2009) Guidance Statement No. 20: Sampling of short range endemic invertebrate fauna for environmental impact assessment in Western Australia;

EPA (2016m) Environmental Factor Guideline: Terrestrial fauna;

EPA & DEC (2010) Technical Guide – Terrestrial vertebrate fauna surveys for environmental impact assessment;

EPA (2016p) Technical Guidance – Terrestrial fauna surveys; and

EPA (2016q) Technical Guidance – Sampling of short range endemic invertebrate fauna.

6.2.3 Receiving environment

The following study has informed this section:

- Terrestrial Fauna Assessment (Ecoscape 2016; Appendix 2)

VERTEBRATE FAUNA

A total of 134 vertebrate fauna species were recorded in the study area (55,000 Ha) over the two phases of assessment, which consisted of 20 species of mammal (12 species of non-volant mammals, eight species of bat), 85 species of bird, 25 species of reptile and four species of amphibian.

No threatened fauna species listed under the EPBC Act were found within the study area. One species of conservation significance was recorded in the study area:

- *Sminthopsis longicaudata* (Long-tailed Dunnart; listed as a Priority 4 species by DPaW).

In addition, *Falco hypoleuca* (Grey Falcon; listed as a Schedule 1 species under the WC Act) was recorded 3.5 km south of the study area, but within the area of the proposed southern access road.

Historic mounds of the *Pseudomys chapmani* (Western Pebble-mound Mouse; listed as a Priority 4 species by DPaW) were recorded throughout the study area. Based on the guide for the indication of presence and activity of the Western Pebble-mound Mouse, all mounds were older than 50 years, indicating no recent or current occupation of this species within the study area.

In addition to the species recorded, the likelihood of each species of conservation significant fauna to occur within the study area was assessed. A total of five conservation significant species have a moderate to high likelihood of occurring within the study area:

- Fork-tailed Swift (Apus pacificus, EPBC Migratory)
- Eastern Great Egret (Ardea modesta, EPBC Migratory)
- Yinnietharra Rock Dragon (Ctenophorus yinnietharra, EPBC Vulnerable)
- Peregrine Falcon (Falco peregrinus, WC Act S7)
- Golden Gudgeon (Hypseleotris aurea, DPaW P2)

The study area was characterised by five habitat types, namely rocky plain (includes undulating hills and lower hillslopes), sandy plain, granite outcrop, major river and minor creek line. Of these, the rocky plain is the most widespread habitat type, followed by sandy plain. The remaining three habitats, granite outcrops, major river and minor creek line were recorded from isolated areas of smaller extent. All habitat types were also recorded from the wider region and are not unique to the study area.

SHORT RANGE ENDEMIC FAUNA

Overall, 935 specimens belonging to 24 species in seven Short Range Endemic (SRE) groups were collected. Pseudoscorpions and terrestrial slaters were most diverse with six and five species, respectively. Spiders, scorpions and centipedes were represented by three species each, and centipedes and snails were present with two species. In total, 27 taxa were recorded from groups that support SRE species. No SRE species of conservation significance were recorded within the study area.

Thirteen potential SRE species were recorded within the study area consisting of:

- Spiders:
  - *Aname* sp. B19
  - *Synothele* sp. B14
  - *Aganippe* sp. B21
- Scorpions:
  - *Lychas* 'hairy tail group'
  - *Lychas* 'multipunctatus group'
- Pseudoscorpions:
  - *Beierolpium* 8/2 sp.
  - *Beierolpium* 8/3 sp.
  - *Linnaeolpium* sp. B04
- Slaters:
  - *Acanthodillo sp. B16*
  - *Buddelundia sp. B59*

    - *Buddelundia sp. B60*
    - *Cubaris* sp. B07
- Centipedes:
    - *Cryptops sp.*

Three potential SRE species occur within the development envelope:

- *Linnaeolpium* sp. B04
- *Beierolpium* 8/3 sp.
- *Aname* sp. B19

The habitat of these species is associated with the dendritic pattern of surface hydrology and groundwater dependent ecosystems, which provide shade, leaf litter and moisture. This is in comparison to the surrounding flat, sparsely vegetated plains and slightly elevated hills, which the majority of the disturbance footprint overlies.

6.2.4 Potential impacts

Potential impacts include:

- Displacement of fauna species.
- Loss of habitat.
- Attraction of feral vertebrates resulting in impacts to native fauna and/or their habitat.

6.2.5 Assessment of impacts

Fauna species are likely to be displaced by the proposal. The proposal will not have a significant impact on conservation significant fauna species or potential SRE species. However, the proposal will remove 1000 Ha of potential habitat. Five habitat types occur within the development envelope (**Table 22**). 75% of the study area is composed of the Rocky Hills and Plains fauna habitat and 12% of the study area is composed of the Sandy Plains fauna habitat. All five habitat types are well represented outside of the development envelope over the larger study area (~55,000 Ha). Minimal impact to habitat types as a result of vegetation clearing will occur because these habitat types are more broadly represented outside of the development envelope (**Table 22**).

Table 22 Fauna habitat in the survey area and indicative footprint

Fauna Habitat	Extent of habitat in the broader survey area (ha)	% of habitat within the survey area	Extent of habitat in the Indicative Footprint (ha)	% of habitat within the Indicative Footprint	% Impact of total mapped habitat extent
Granite Outcrop	2,609.1	4.9	61.8	6.8	2.4
Major River	1,890.1	3.5	0.7	0.1	0.04
Minor Creekline	2,973.0	5.6	53.3	5.8	1.8
Rocky Plains and Hills	40,265.0	75.2	687.9	75.4	1.7
Sandy Plains	5,812.4	10.9	108.5	11.9	1.9
Total	**53,549.6**		**912.3**		2

Feral fauna may be attracted to the proposal areas due to:

- increased water availability from dripping taps and leaking pipes,
- potential for humans to feed feral animals, and
- available food waste in the landfill facility.

The presence of increased numbers of feral fauna will result in impacts to native fauna and native fauna habitat.

6.2.6 Mitigation

Hastings commits to the following mitigation of potential impacts:

- Exclusion of disturbance within 150 metres of Yangibana and Fraser's Creeks, with the exception of linear infrastructure crossings.
- Fauna Management Plan (to be developed), will include consideration of:
  - feral fauna: Training and awareness of workforce i.e. will not feed feral animals, trapping program,
  - non-native fauna: consideration of pastoral activities, training and awareness, speed limits in vicinity of cattle grazing, land access requirements during mustering activities (in consultation with the pastoralist), and
  - native fauna: training and awareness, snake handling, speed limits, incident reporting, egress from trenches and inspection of trenches and lined ponds during construction.

- Land Management Plan (to be developed) will include the management of putrescible waste to deter feral fauna.
- Water Management Plan (to be developed) will include consideration of:
    - inspection and monitoring program of pipelines and facilities where water is used (e.g. waste water treatment plant),
    - fencing of evaporation pond, and
    - bird deterrents around evaporation pond.

6.2.7 Predicted outcome

The proposal will displace fauna and result in impact to 1000 Ha of fauna habitat, which is well represented outside of the development envelope. All conservation fauna and their habitat are represented outside the development envelope. Potential impacts of feral fauna can be mitigated and thus meet the EPAs objective for the environmental factor, terrestrial fauna:

To protect terrestrial fauna so that biological diversity and ecological integrity are maintained.

6.3 Hydrological processes

6.3.1 EPA objective

To maintain the hydrological regimes of groundwater and surface water so that environmental values are protected.

6.3.2 Policy and guidance

Laws and regulations relevant to the consideration of hydrological processes include:

Country Areas Water Supply Act 1947 (WA)

Environmental Protection Act 1986 (WA)

Rights in Water and Irrigation Act 1914 (WA)

Relevant guidelines include:

ANZECC and ARMCANZ (2000) Australian and New Zealand guidelines for fresh and marine water quality;

DFAT (2016) Water Stewardship - Leading Practice Sustainable Development Program for the Mining Industry;

DoW (2009a). Hydrogeological reporting associated with a groundwater well licence;

DoW (2009b) Water quality monitoring program design: A guideline for field sampling for surface water quality monitoring programs;

DoW (2011) Use of operating strategies in the water licencing process; and

EPA (2016g) Environmental Factor Guideline: Hydrological processes.

6.3.3 Receiving environment

The following studies have informed this section:

- Conceptual Hydrogeological Assessment (Global Groundwater 2016; Appendix 4-1)
- Hydrogeological Assessment (GRM 2017; Appendix 4-2)
- Preliminary Surface Water Assessment (JDA 2016; Appendix 4-3)

HYDROGEOLOGY

The study area is located within the Bangemall/Capricorn Groundwater subarea of the Gascoyne Groundwater area. Groundwater resources within the subarea comprise alluvium, calcrete, palaeochannel and fractured rock aquifers (Global Groundwater 2016; **Figure 9**).

The hydrogeology of the area is characterised by a westerly draining system, consistent with the surface water regime. Superficial sediment cover is typically thin, with thicker sequences confined to the creek beds and drainage systems. Calcrete units up to about 30 m thick can occur along the major drainage lines.

Groundwater occurrences within the area predominantly occur as fractured bedrock aquifers, whereby permeability in the natural rock is enhanced by fracturing, dissolution and chemical weathering. Away from the fractures permeability in the bedrock is low. Modest supplies can also occur in calcrete aquifers, where the calcrete units are sufficiently thick to extend below the water table. Small amounts of groundwater can occur in alluvium associated with the larger drainage systems. However away from the larger drainage systems the alluvium is typically of insufficient depth to extend below the water table.

The nature of rainfall in the region produces periods of high runoff to creeks and rivers. This in turn produces sporadic recharge to permeable units (e.g. permeable alluvium and calcrete along the drainages or where fractured basement rocks contact surface drainage lines, in areas where the runoff is concentrated). Groundwater recharge by direct infiltration of rainfall over the superficial units or fractured outcropping rocks will likely be minor (Global Groundwater 2016).

Field investigations were undertaken by GRM (2017) to estimate the dewatering requirements for the proposed pits and assess the water supply potential from fractured rock aquifers. The calcrete aquifers were not assessed as part of this study. The field investigations comprised:

- the collection of hydrogeological data from seven resource exploration drill holes,
- airlift recovery testing on 15 existing resource drill holes, and
- the installation and test pumping of three test production bores (one at each of the three[3] proposed pit locations).

The results of the field investigations indicate that modest groundwater inflows are likely, which will be associated with an aquifer unit comprising the vuggy ironstone veins which host the orebody. The ironstone veins strike in a north south direction in Fraser's and Bald Hills, swinging to a north-west south-east direction at Yangibana. The ironstone veins dip steeply to the west (or south west at Yangibana), extending above the water table on the up-dip side. The veins are thought to extend down dip and along strike from each of the pits.

The permeability away from the ironstone structures is low to very low. Analysis of the airlift recovery data indicates the hydraulic conductivity of the aquifer averages about 2.5 m/day at Fraser's to 5 m/day at Bald Hills and Yangibana. The thickness of the aquifer varies from 1m to over 10 m thick, with an average thickness of about 5 m at Fraser's and 4 m at Bald Hills and Yangibana.

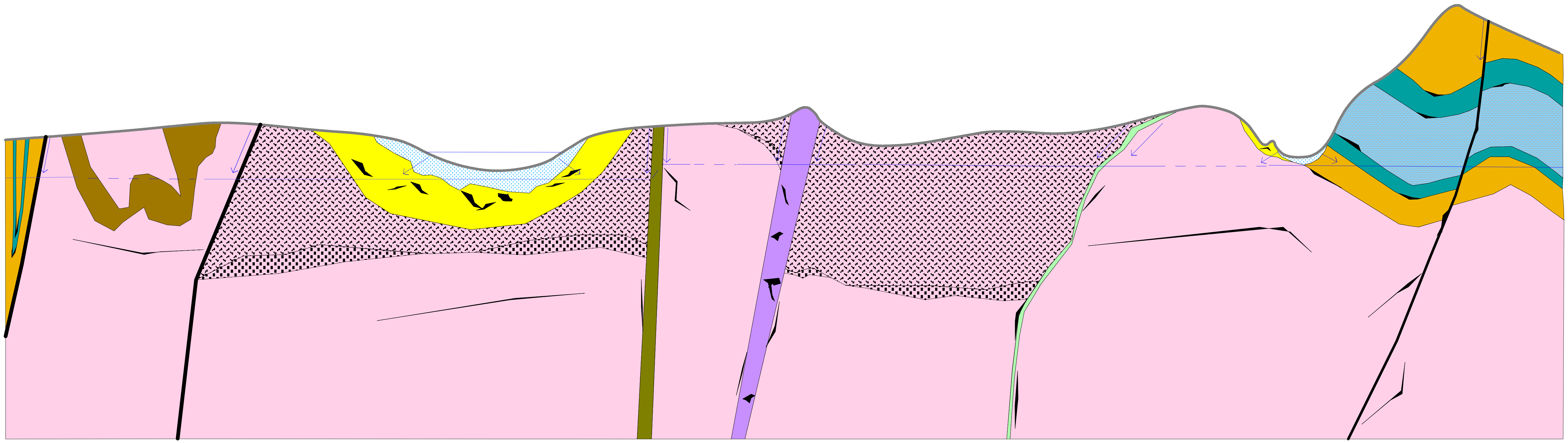
The production bores installed at Fraser's and Bald Hills targeted a thickened sequence of ironstone, which will be suitable as a construction and operational water supply for the project. The bores were constructed using 155 mm Class 9 uPVC casing, and test pumped for a period of 48 hours. The analysis of the test pumping data indicates a long-term yield of 6 L/sec and 8 L/sec for the Fraser's and Bald Hills bores respectively.

The test bore installed at Yangibana intercepted a thinner sequence of ironstone and is within the proposed pit. This bore was installed for test purposes only and is not expected to be used as a primary water supply bore for the project. However, an alternate location for a primary supply bore was identified later in the investigation.

The field investigation indicates that the depth to groundwater in the pit areas are approximately 309 mRL at Fraser's, 316 mRL at Bald Hills and 323 mRL at Yangibana. Groundwater samples were collected from each of the production bores at the end of the test pumping. Water quality analyses of the samples indicates a pH range of 7.8 to 8.5 and a salinity range of 920 to 1,200 mg/L TDS.

[3] Note that Yangibana deposits will be initially two pits (Yangibana North and Yangibana West deposits) but for the purposes of the assessment were considered as one pit due to their close proximity.

Conceptual Hydrogeology Yangibana Area - Schematic Section



Broad Units

- Alluvium
- Calcrete
- Quartz Veins
- Ironstone Veins
- Dolerite Dykes
- Dolerite - Gabbro Sills
- Bangemall Supergroup Rocks
- Pimbyana and Yangibana Granites
- Pooranoo Metamorphics

Secondary Porosity Freatures

- Weathered - Low permeability eluvium
- Weathered - Higher permeability saprolite
- Faults
- Fractures - Solution Channels and Cavities

Watertable

- Mapable
- Difficult to immediately establish

Main Hydrogeological Characteristics

A series of generally discontinuous aquifers, often disconnected and of mostly limited extent. Psuedo discontinuous watertable.

Main Aquifers

Alluvium and calcrete along the larger drainages, ironstone veins where secondary porosity developed, saprolite where developed above fresh granites and ocassional fractures in basement rocks.

- Alluvium holds groundwater in primary porosity but has generally limited extent and is thin with little saturated thickness.
- Calcrete holds groundwater in secondary porosity of solution channels and cavities but can be clayey.
- Ironstone veins hold groundwater in secondary porosity of soultion channels and cavities but are of limited extent.
- Saprolite developed over fresh granitic basement rocks will hold water in secondary porosity but its extent is unknown.
- Fractures in basement rocks will hold water in secondary posrosity but will be almost impermeable whrere fresh and unfractured.

Recharge

Occurs mostly where accumulated runoff coincides with alluvium-calcrete and structure with less direct infiltration of rainfall over outcrop.

Hydraulic Characteristics

Permability will be extremely high where solution channels and cavities or open fractures are developed and may be high in saprolite but will be very low elsewhere.

Storage very low overall. Greatest storage will occur in saturated alluvium and calcrete as well as saprolite and lower permeability eluvium over saprolite.

Figure 9 Yangibana conceptual hydrogeology

HYDROLOGY

Rainfall in the Gascoyne region occurs from two types of meteorological events:

- rare and high intensity rainfall resulting from tropical cyclonic activity, and
- frequent, lower intensity rainfall resulting from low pressure systems, localised thunderstorms or tropical upper air disturbances.

Average annual rainfall for the region is between 210 and 278 mm. The proposal area predominantly receives rainfall between January and June.

The proposal is located within a catchment of approximately 11,000 km^2 on the Lyons River. The Lyons River, a tributary of the Gascoyne River, is associated with the southern portion of the study area, and flows in a north-westerly direction. The Edmund River, a tributary of the Lyons River, traverses the western edge of the study area and flows in a southerly direction. Both rivers are considered to be ephemeral, and only flow after rainfall. Semi-permanent pools occur along their length. Several tributaries of these rivers traverse the study area: Yangibana Creek and Fraser Creek are the main tributaries of the Lyons River, which occur within the study area and flow in a southerly direction.

The soils of the catchment areas are predominantly shallow sandy loams overlying weathered granite or clayey loams. This limits the capacity for rainfall infiltration into the soil.

6.3.4 Potential impacts

The potential impacts to hydrological processes as a result of implementing the proposal include:

- Potential water drawdown impacts to groundwater dependent ecosystems and the Gifford Creek PEC.
- Flooding and inundation from surface water events due to presence of linear infrastructure.
- Shadow effects (i.e. obstruction of surface water flow pathways) due to presence of linear infrastructure.
- Erosion and sedimentation as a result of surface water flow.

6.3.5 Assessment of impacts

WATER DRAWDOWN

Pit dewatering, including the two existing production bores, is expected to satisfy approximately 20% of this demand in the initial stage of the project, increasing to 90% towards the end of the mine life. The remainder of the demand is expected to be met by a network of water supply bores located along the ironstone aquifer away from the pits.

Three dimensional groundwater flow modelling was undertaken (GRM, 2017) for the proposed pits to estimate dewatering rates for the project. The rates are based upon sump pumping, augmented at Fraser's and Bald Hills by abstraction from the two existing production bores.

Sensitivity analysis was also conducted to provide a range of possible dewatering rates, by varying hydraulic parameters within likely ranges (refer to the GRM (2017) report for further details). The predicted dewatering rates for the three proposed pits are provided in **Table 23**.

Table 23 presents base case (i.e. expected conditions), as well as the potential range, as provided by the sensitivity analysis.

Table 23 Model simulated dewatering rates

Mining Year	Model Simulated Dewatering Rates (L/sec)			
	Fraser's	Bald Hills	Yangibana	Total
Year 1 – Base Case (Potential Range)	6 -	8 -	- -	14 -
Year 2 – Base Case (Potential Range)	6 -	8 -	- -	14 -
Year 3 – Base Case (Potential Range)	6.1 -	8.5 -	- -	14.6 -
Year 4 – Base Case (Potential Range)	12.5 6.8 to 20	17 8.4 to 23	2.3 2.3 to 2.4	31.8 17.5 to 45.4
Year 5 – Base Case (Potential Range)	(10) -	(14) -	7.5 6.2 to 7.5	7.5 6.2 to 7.5
Year 6 – Base Case (Potential Range)	(10) -	(14) -	25 22 to 33	25 22 to 33
Year 7 – Base Case (Potential Range)	(10)	(14)	51 27 to 55	51 27 to 55

* The figures in brackets represent additional water supply potential for the project, if required, i.e. sump pumping and bore abstraction after mining has ceased.

Model simulated drawdown contours at the end of mining are provided as **Figures 10 to 12**. The asymmetrical drawdown reflects the geometry of the aquifer (i.e. the steep hydraulic gradient corresponds to the ironstone extending above the water table up-dip). The modelling indicates that the 5 m drawdown contour extends up to 1.5 km, 1.25 km and 2 km from the proposed Fraser's (**Figure 10**), Bald Hills (**Figure 11**) and Yangibana pits (**Figure 12**), respectively. During operations, water drawdown contours occur within the range presented for end of mining (GRM 2017).

The drawdown impact associated with pit dewatering is considered minor due to the confined fractured rock aquifers, low exposure of sensitive receptors (i.e. GDE, Gifford Creek PEC) in near vicinity of water drawdown and relatively shallow pit depths. Consideration of impacts to groundwater dependent ecosystems and the Gifford Creek PEC are discussed in sections 5.2 and 5.3, respectively.

Pit lake modelling (GRM 2017) was undertaken to assess pit conditions post closure. The pit lake modelling allows for inflows to the pits (rainfall and groundwater inflows) and outflows from the pits (evaporation and groundwater outflows). Four model runs were completed for each pit based on the following conditions:

- pit catchment comprising pit only, with average rainfall conditions,
- pit catchment comprising pit only, with high rainfall conditions,

- pit catchment plus 20%, with average rainfall conditions, and
- pit catchment plus 20%, with high rainfall conditions.

The pit lake modelling indicates that after mine closure the water level in the pits will rise for approximately 20 years, until equilibrium is reached. Equilibrium is achieved once evaporation equals the sum of rainfall and groundwater inflows. The modelling indicates that under all scenarios, the pit lake level will remain below the ambient groundwater level over the 500 year simulation period. This condition is termed a groundwater 'sink' and prevents water, which becomes concentrated in salts over time, from discharging to the down-gradient groundwater environment.

FLOODING AND SHADOW EFFECTS

A detailed hydrological model has been developed for Fraser, Yangibana and Gifford Creeks, as well as the Lyons River adjacent to the study area, to assess flood conditions that will likely impact on the proposed mine infrastructure (JDA 2016). Peak flows for the 18% to 1% Annual Exceedance Probability (AEP; 5, 10, 20, 50, 100 year average recurrence interval (ARI)) events and the probable maximum precipitation (PMP) were estimated for the proposal and for the Lyons River Catchment using a two dimensional (2D) hydrodynamic flood model (MIKE21FM) rain on grid approach. The detailed model allowed for accurate delineation of flood extent, depth (i.e. drying depth, flooding depth and wetting depth), flow rates and velocities. The modelling resulted in the following conclusions:

- Both the Bald Hill and Frasers Pits sit almost directly on the upper reaches of these tributaries, as such local drainage is away from the site.
- No notable drainage paths are located within the processing plant and there is only minor risk from tributaries to the north and south of the processing plant.
- The haul road corridor to the south of Bald Hill traverses the alignment of a small drainage system and also crosses a more significant drainage path.
- The Yangibana North footprint is located in the upper reaches of Yangibana Creek within a number of minor tributaries. Surface water flows occur within ephemeral drainage lines in south-west direction. The waste rock landforms and open pits are exposed to surface water flow without mitigation. Diversion of these drainage networks is required to protect the integrity of proposed waste rock landforms and to prevent flooding of the open pits.
- Flood waters from Yangibana Creek, Frasers Creek and Lyons River traverse either the main access road or the haul road. No impacts are expected as a result of this because floodways would be constructed flush with the natural creek invert.
- The southern access road is a 7.5 km stretch of proposed access road running in a north-west direction from Cobra/Gifford Creek Road towards the Study Area (parallel with Gifford Creek). The current alignment has the road crossing a number of minor ephemeral drainage courses, which ultimately feed Gifford Creek and thus may obstruct surface water flow.

Large sections of the Mining Area are unaffected by flood flows, other than shallow, localised overland runoff, which can be managed. Based on JDAs assessment (2016), a combination of diversion channels, floodways and culverts are required to mitigate impacts associated with surface water flows in specific areas of the Proposal.

EROSION AND SEDIMENTATION

Flow velocities at points where the road crosses the Lyons River, Yangibana Creek, or Frasers Creek are likely to be in excess of 1.9 m/s in events greater than 5% AEP (20 year ARI). Sedimentation and erosion are likely if mitigation is not implemented.

6.3.6 Mitigation

Best Practice

- A hydrological model has been developed to identify specific areas where linear infrastructure may obstruct surface water movement.
- Hydrogeological modelling has been undertaken to determine the drawdown impacts to the surrounding environment, and assess post closure pit void conditions at each location.

Avoidance

- Infrastructure has been located out of the flood plain, where possible.

Minimisation

- Linear infrastructure has been moved to reduce the number of crossings of creeks and drainage channels thus reducing the risk of obstructing surface water flow during heavy rainfall events.
- Water reuse and recycling has been incorporated into the design of the processing plant to reduce groundwater demands for the proposal.

Management

- Diversion channels, flood-ways and culverts will be included in the detailed design of the proposal's infrastructure.
- Consideration of rip-rap protection upslope and downslope of the floodways at river and creek crossings.
- The groundwater operating strategy (as a component of water licence applications) will include consideration of:
    - Monitoring water abstraction
    - Water quality monitoring
    - Groundwater level monitoring
    - Monitoring bores
    - GDE health monitoring
    - Contingency planning

Rehabilitation

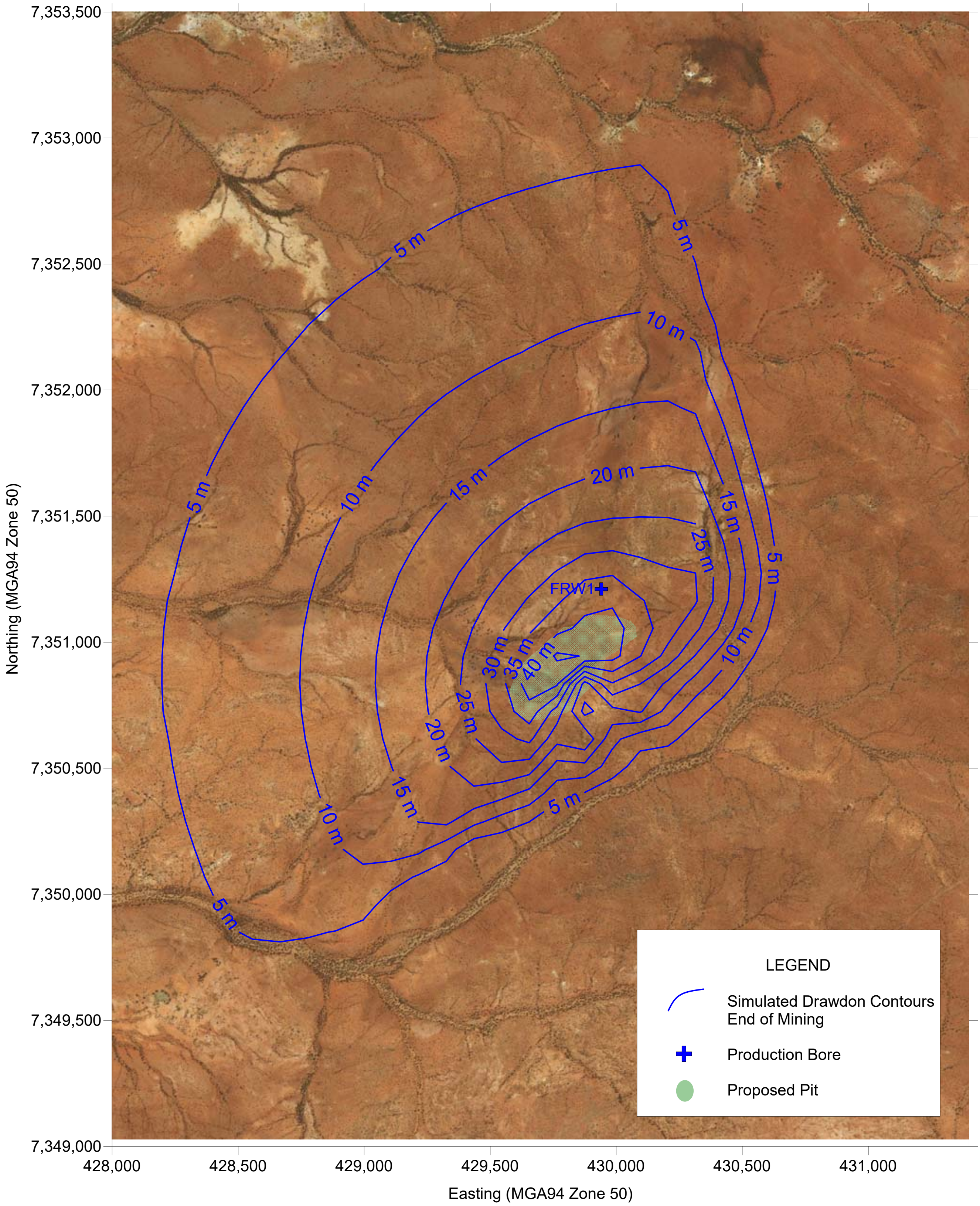
- Preliminary Mine Closure Plan (Appendix 6)

6.3.7 Predicted outcome

The above mitigation will ensure potential impacts are unlikely to occur thus satisfying the EPA objective:

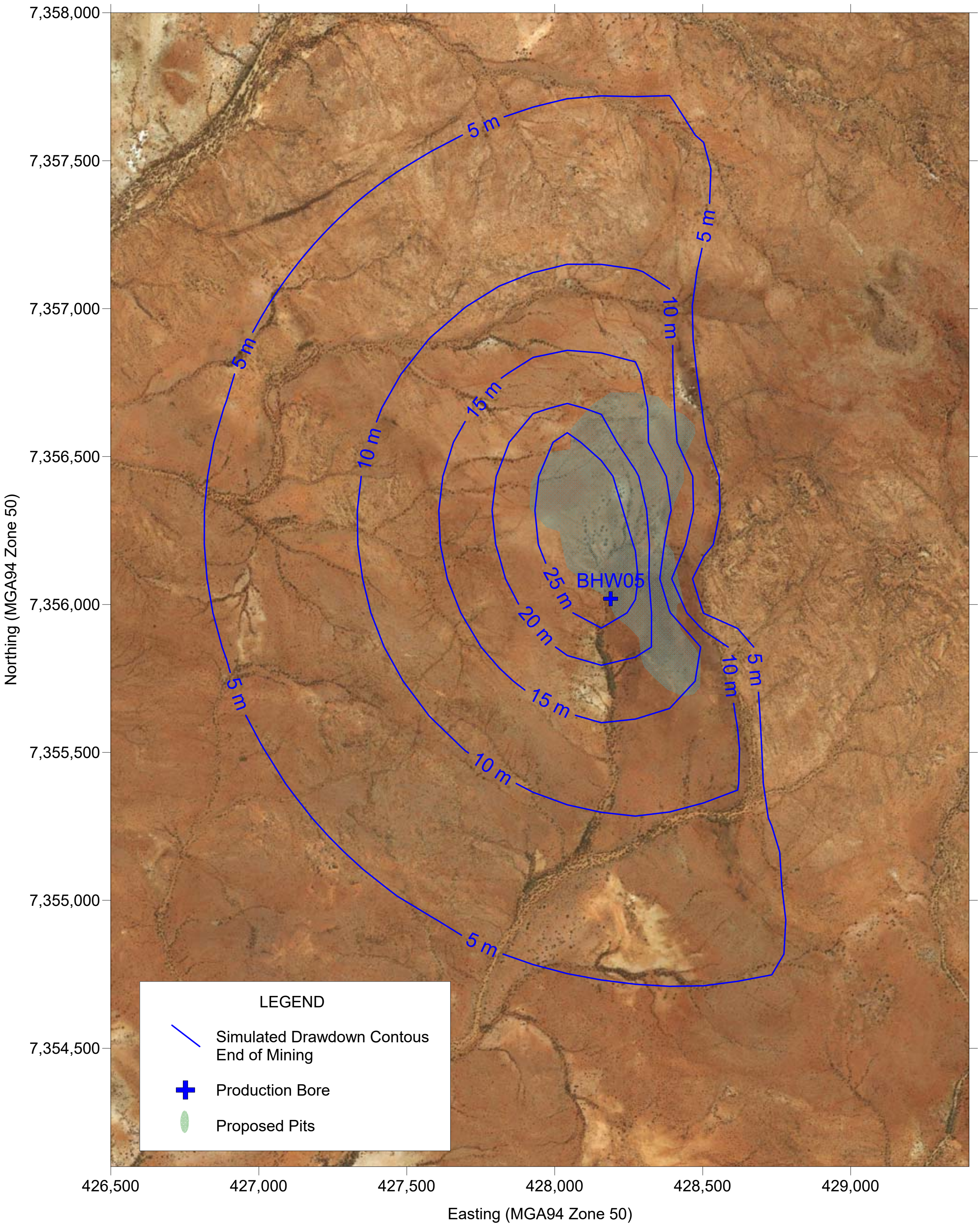
To maintain the hydrological regimes of groundwater and surface water so that environmental values are protected.

Insert fig 8



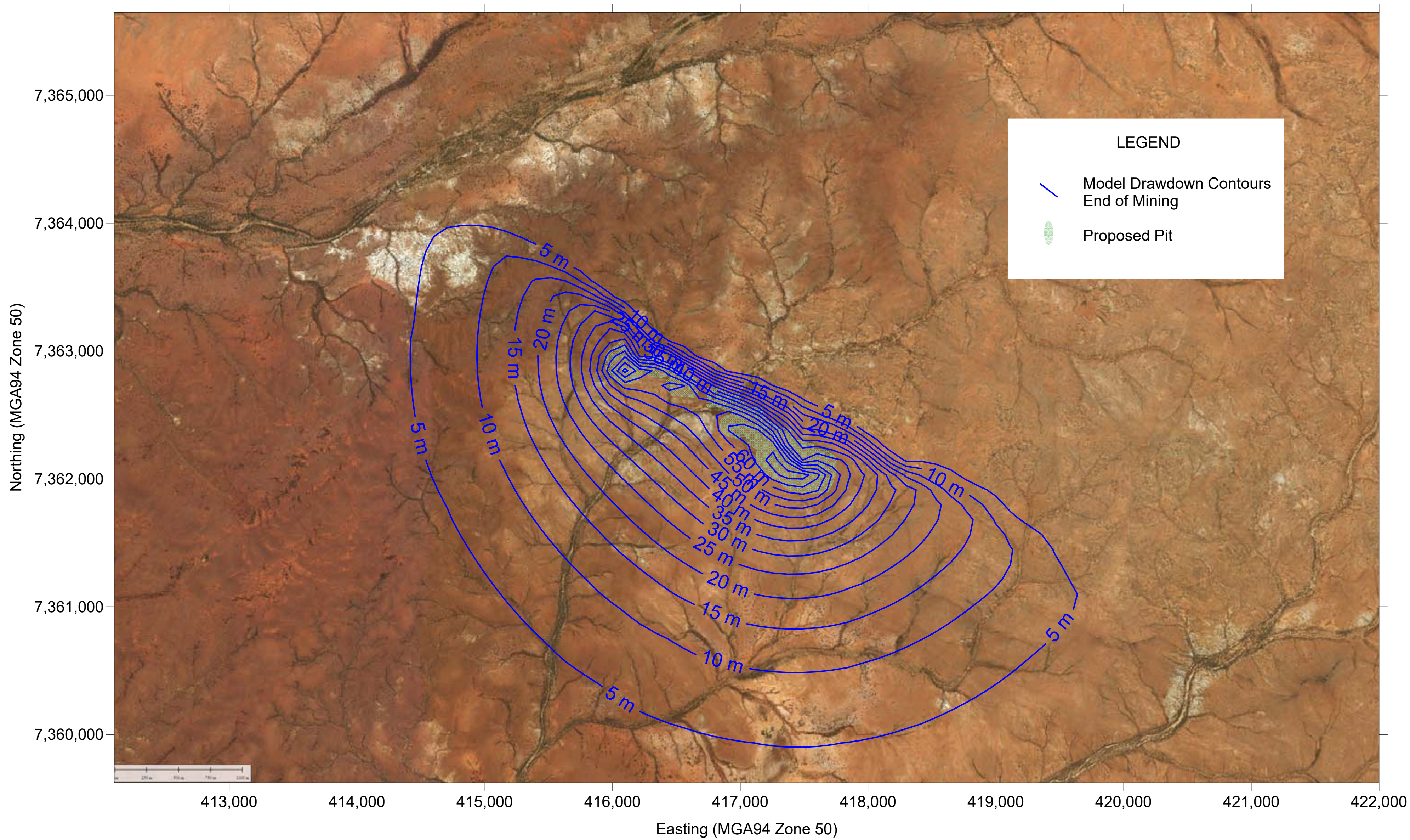
Yangibana DFS (J160014R01)			**FRASER'S MODEL SIMULATED DRAWDOWN CONTOURS END OF MINING**	GROUNDWATER RESOURCE MANAGEMENT
Hastings Technology Minerals Ltd				
KM	Jan 2017	**FIGURE 10**		

FILE://Jobs2016/J160014_Yangibana/figures/surfer/frasers_modelling_results.srf



Yangibana DFS (J160014R01)			BALD HILLS MODEL SIMULATED DRAWDOWN CONTOURS END OF MINING	GROUNDWATER RESOURCE MANAGEMENT
Hastings Technology Minerals Ltd				
KM	Jan 2017	**FIGURE 11**		

FILE://Jobs2016/J160014_Yangibana/figures/surfer/baldhill_modelling.srf



Yangibana DFS (J160014R01)		
Hastings Technology Minerals Ltd		
KM	Jan 2017	FIGURE 12

YANGIBANA MODEL SIMULATED DRAWDOWN CONTOURS END OF MINING

GROUNDWATER RESOURCE MANAGEMENT

FILE://J160014_Yangibana/figures/surfer/yangibana_drawdown.srf

6.4 AIR QUALITY

6.4.1 EPA objective

To maintain air quality and minimise emissions so that environmental values are protected.

6.4.2 Policy and guidance

Laws and regulations relevant to the consideration of air quality include:

Environmental Protection Act 1986 (WA)

National Greenhouse and Energy Reporting Act 2007 (Commonwealth)

Relevant guidelines include:

CER (2016a) National greenhouse and energy reporting (measurement) determination;

CER (2016b) National greenhouse and energy reporting system measurement technical guidelines (NGER Technical Guidelines);

DEC (2005) Approved methods for the modelling and assessment of air pollutants in New South Wales;

DER (2015) Draft Guidance Statement: Environmental risk assessment framework;

DoEE (2016) National greenhouse accounts factors;

EPA (2016a) Environmental Factor Guideline: Air quality;

NEPM (2016) National environmental protection (ambient air quality) measure.

NPI (2012) Emission estimation technique manual for mining version 3.1.

6.4.3 Receiving environment

The following studies have informed this section:

- Air Quality Assessment (Pacific Environment 2016; Appendix 7-1)
- Memo: Radon and Thoron Modelling (Pacific Environment 2016; Appendix 7-2)
- Greenhouse Gas Emissions Assessment (Pacific Environment 2017; Appendix 7-3)

The Gascoyne Mid-West region is bushfire prone with these generally occurring between October and February. Background dust levels will be elevated during this time (AIC 2008).

The key sensitive receptor located closest to the operations was identified as the accommodation facility. Modelled ambient air quality concentrations were determined at this location. For consideration of radon and thoron emissions, Edmund and Gifford Creek homesteads were considered as key sensitive receptors.

There is no publically available information on PM10 monitoring undertaken in the inland Gascoyne region. As such reference was made to the available air quality information within Newman as used by BHP Billiton Iron Ore in their *Pilbara Strategic Environmental Assessment – Cumulative Air Quality Assessment* (Pacific Environment 2015). The background concentrations within the Proposal development envelope are indicative of what will be received in the Pilbara due to similar:

- climate,
- background influences i.e. dust storm and wildfire events, and

- land use.

The background concentrations were chosen based on the maximum 70th percentile of either 2010 or 2011 from the monitoring station:

- a TSP background of 35 µg/m^3, and
- a PM10 background of 19 µg/m^3.

In the absence of TSP monitoring data within the Proposal development envelope, background TSP levels are taken as twice the PM10 background adopted for the assessment. This approach is considered conservative. There is also no PM2.5 monitoring available and thus the background levels are assumed to be 15% of the PM10 used for the assessment.

6.4.4 Potential impacts

The construction phase activities are expected to contribute particle (dust) emissions as a result of earthworks, mainly:

- Preparation of the site for mining and support activities, including initial clearing /disturbance of vegetation
- Construction of mine pits and infrastructure, processing plant, roads, support facilities.

The key pollutant emission sources during operations are:

- Mining operations
  - Blasting
  - Drilling
  - Material loading by excavators
  - Material unloading from haul trucks
  - Wheel generated dust from haul roads
  - Bulldozers on ore and waste rock
  - Conveyors
  - Wind erosion from stockpiles and open areas
  - Material loading into crusher by front end loader
- Processing plant operations
- On site power generation

Pollutants from the above emission sources include:

- Particles, as PM10, PM2.5 ,TSP and dust deposition
- Oxides of nitrogen (NOx) as nitrogen dioxide (NO2)
- Radon and thoron

Key sources of greenhouse gas emissions include:

- Diesel power generation
- Diesel used for stationary energy purposes
- Diesel used for transport energy purposes

- LNG for acid bake kilns
- Landfill
- Waste water handling

Implementation of the proposal will result in emissions of the following greenhouse gases:

- Carbon dioxide
- Methane
- Nitrous Oxide

Specifically, the acid bake kiln (in the processing plant) will produce the following impurities:

- Sulfur trioxide
- Sulfur dioxide
- Hydrogen sulphate
- Carbon dioxide
- Dust

6.4.5 Assessment of impacts

Modelled ground level concentrations for key pollutants of interest have been compared to ambient air quality assessment criteria in order to determine the potential impact (Pacific Environment 2016; Appendix 7-1). The assessment has considered the potential impact associated with the proposal, as well as the cumulative impact (i.e. in conjunction with the existing air quality of the project area). The assessment has been made generally across the model domain, as well as at key sensitive receptor locations identified as being representative of protected environmental values.

Ambient air quality criteria are provided by the Department of Environmental Regulation (DER) as part of its Environmental Risk Assessment Framework (DER 2015). There is no formal dust deposition criterion available in WA. As such reference has been made to the New South Wales (NSW) criteria (DEC, 2001) for deposited dust, which are normally applied for assessments in WA. The NSW criteria set a maximum increase of 2 g/m^2/month in dust levels with a maximum total deposited dust level of 4 g/m^2/month. Deposited dust is assessed as insoluble solids as defined by AS 3580.10.1-1991. It is noted that the above criterion were set to address nuisance dust and not as an indicator for assessing impact on vegetation.

The modelling results in isolation of other emission sources in the region indicates that the predicted ground level concentrations of TSP, PM10 , PM2.5, dust deposition and NO2 are not significant, by comparison to the relevant criterion at receptor locations.

The proposal emissions were also modelled in conjunction with an estimate of background emissions, to estimate the potential cumulative impact on the environment. In the absence of site specific background monitoring information, conservative background levels were adopted for pollutants and the cumulative impact should be considered in conjunction with background levels adopted. Given the remoteness of the proposal, background levels for NO2 are assumed negligible.

Both short term impacts (24-hour timeframe) and longer term impacts (1-year) were considered. The modelling results for the proposal indicate that the predicted ground level concentrations for:

- Cumulative 24-hour TSP can be expected to be around 34.6 µg/m^3 (44% of the criteria concentration of 82 µg/m^3).
- Cumulative 24-hour PM10 can be expected to be around 20.3 µg/m^3 (44% of the criteria concentration of 46 µg/m^3).
- Cumulative annual average PM10 can be expected to be around 19.2 µg/m^3 (70% of the criteria concentration of 27.5 µg/m^3).
- Cumulative 24-hour PM2.5 can be expected to be around 3.1 µg/m^3 (14% of the criteria concentration of 23 µg/m^3).
- Cumulative annual average PM2.5 can be expected to be around 2.9 µg/m^3 (41% of the criteria concentration of 7 µg/m^3).
- Excluding background, the maximum monthly dust deposition is predicted to be 0.014 g/m^2/month, at less than 0.7% of the criteria concentration of 2 g/m^2/month.
- Cumulative 1-hour NO2 can be expected to be less than 2% of the criteria concentration of 226 µg/m^3.
- Cumulative annual average NO_2 can be expected to be around 13% of the criteria concentration of 56 µg/m^3.

At the identified receptor, the cumulative NO_2 concentrations are within the criteria for both 1-hour and annual averaging periods.

The maximum radon and thoron concentrations predicted to occur at the accommodation camp are 3.1×10^{-3} Bq/m^3 and 1.3×10^{-8} Bq/m^3, respectively. These figures were used to inform calculations of dose exposure estimates discussed under Section 5.6: Human Health, which were also shown to be well below criteria levels and thus not harmful to humans.

The total scope 1 greenhouse gas emissions associated with the normal operating scenario are 12,937.4 tCO_2-e and are expected to contribute approximately 0.002% of the 2014 Australian emissions. These emissions also represent approximately 0.087% for the mining sector, 0.016% of Western Australia and around 0.003% of the Australian Government's 2020 emissions target. There are no scope 2 emissions associated with the proposal. Of the total scope 1 greenhouse gas emissions, 3,877 tCO_2-e are estimated from the acid bake kiln operations in the processing plant.

6.4.6 Mitigation

Hastings commits to the following mitigation of potential impacts:

BEST PRACTICE

- Implement a continual improvement program including consideration of:
    - selection and use of fuel efficient mobile equipment (on-site vehicles) and stationary equipment (generators),
    - driver education to reduce diesel consumption,
    - optimisation of activities and logistics to reduce diesel consumption,
    - optimise operations to minimise time of operation at low efficiency levels that may result in elevated greenhouse gas emissions, and
    - efficiencies in vehicle maintenance and replacement.

- Inpurities from the acid bake kiln will be removed via a combination of scrubbers and a precipitator (note, the final design will be based on outcomes of the pilot plant), and gauges will monitor the efficiency of the equipment.

MINIMISATION

- Implement a solar farm to reduce the proposals diesel requirements.

MANAGEMENT

- Land Management Plan (to be developed) will include implementation of the waste mitigation hierarchy to reduce waste to landfill (discussed further in Section 5.4).

6.4.7 Predicted outcome

The assessment of impacts demonstrated that the emissions from the Proposal with the potential to impact air quality are relatively low. However, in line with best practice, further considerations will be implemented to maintain air quality and minimise emissions thus satisfying the EPA objective for the environmental factor, air quality:

To maintain air quality and minimise emissions so that environmental values are protected.

6.5 Social surroundings

6.5.1 EPA objective

To protect social surroundings from significant harm.

6.5.2 Policy and guidance

Laws and regulations relevant to the consideration of social surroundings include:

Aboriginal Heritage Act 1972 (WA)

Environmental Protection Act 1986 (WA)

Environmental Protection (Noise) Regulations 1997 (WA)

Heritage of Western Australia Act 1990 (WA)

Protection of Moveable Cultural Heritage Act 1986 (Commonwealth)

Relevant guidelines include:

Australian/New Zealand Standard 2107:2000 'Acoustics – Recommended design sound levels and reverberation times for building interiors';

DAA/DPC (2013) Aboriginal heritage due diligence guidelines;

DER (2016) Draft guideline on environmental noise for prescribed premises;

EPA (2004c) GS 41 Guidance for the Assessment of Environmental Factors: Assessment of Aboriginal heritage;

EPA (2014) EAG 13 Environmental assessment guideline for consideration of environmental impacts from noise; and

EPA (2016j) Environmental Factor Guideline: Social surroundings.

6.5.3 Receiving environment

The following studies have informed this section:

- Visual Amenity Report (Ecoscape 2016c; Appendix 8-1)
- Noise Assessment Report (Herring Storer Acoustics 2016; Appendix 8-3)
- Air Quality Assessment (Pacific Environment 2016; Appendix 7-1)

<u>Visual Amenity</u>

The proposal is situated in a remote area characterised by flat and uniform landforms and low vegetation. Approximately 18 homesteads occur within a 100 km radius of the proposal. Of the 18 homesteads, Cobra Station is considered a historically significant site and tourist attraction. The proposal is also located approximately 80 km from Mt Augustus, a significant tourist attraction. Public roads within 100 km of the proposal include the Cobra Gifford Creek Road, Cobra Mount Augustus Road and the Dooley Downs Road.

HERITAGE

There are eight Western Australian listed Commonwealth Heritage Places in the Upper Gascoyne LGA:

1. Cobra Station Homestead, Cobra - Mount Augustus Rd, Bangemall via Gascoyne Junction, WA, Australia: Indicative Place on the Register of the National Estate.
2. Fossil Hill, Bidgemia Station, WA, Australia: Registered Place on the Register of the National Estate.
3. Indigenous Place, Mount Augustus National Park, WA, Australia: Registered Place on the Register of the National Estate.
4. Indigenous Place, Waldburg Station via Gascoyne Junction, WA, Australia: Registered Place on the Register of the National Estate.
5. Kennedy Range Area, Gascoyne Junction, WA, Australia: Registered Place on the Register of the National Estate.
6. Mount Augustus Area, Mount Augustus via Gascoyne Junction, WA, Australia: Registered Place on the Register of the National Estate.
7. Nundigo Well and Stockyard, Landor Station via Meekatharra, WA, Australia: Indicative Place on the Register of the National Estate.
8. Top Camp Unconformity, Ashburton Downs Station, via Paraburdoo, WA, Australia: Indicative Place on the Register of the National Estate.

There are no Commonwealth Heritage Places within or immediately surrounding the proposal. The Mt Augustus Area is the nearest listed Commonwealth Heritage Place, which is located approximately 80 km from the proposed action.

There are no State listed Heritage Places within or immediately surrounding the proposal. The nearest sites listed on *inHerit* (State Heritage Office, Heritage Council, Government of Western Australia) are:

- Bangemall Wayside Hotel (fmr), Cobra Station (Cobra Station Homestead (fmr), Euranna Hotel; Heritage Place No. 4129).
- Cobra Station Homestead – Original, Cobra-Mt Augustus Rd Bangemall via Gascoyne Junction (Heritage Place No. 15419).

ABORIGINAL HERITAGE

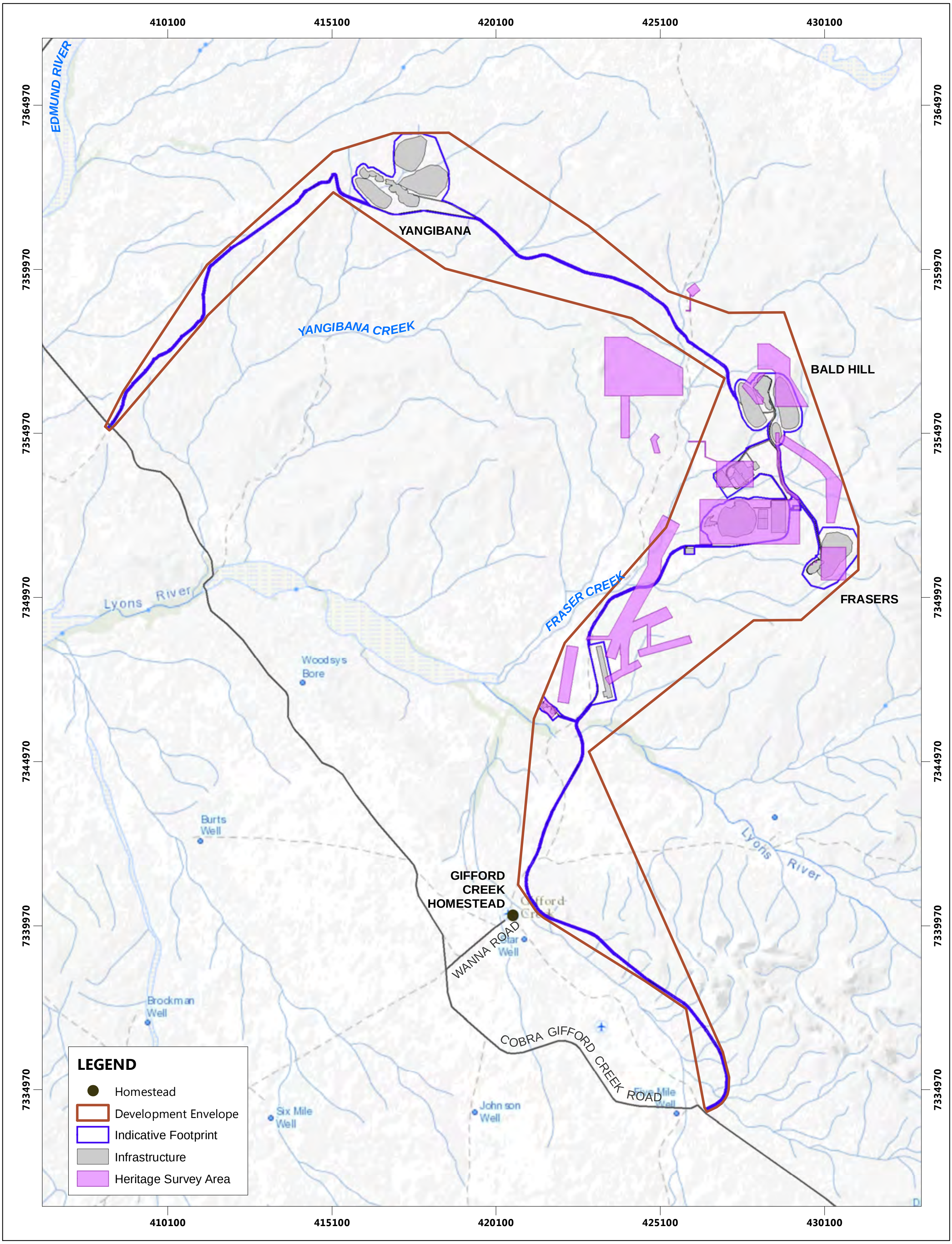
Hastings works closely with the Traditional Owners (Thin-Mah Warianga, Tharrikari, Jiwarli) to identify indigenous heritage values. The majority of the areas to be disturbed by the proposal have been surveyed (**Figure 13**). All surveys conducted to date have been undertaken in accordance with the *Aboriginal Heritage Act 1972* (WA). There is one registered site of heritage significance in the vicinity of the project area according to the (WA) Department of Aboriginal Affairs register, however other sites have been identified during the surveys. The majority of sites of heritage significance occur outside the development envelope and are closely associated with the Lyons River, Fraser Creek and Gifford Creek.

During heritage surveys, several sites were found within or adjacent to the Proposal areas (Brad Goode and Associates, 2016). The survey participants also requested that:

- a 150m exclusion buffer zone is placed on either side the Lyons River, Fraser Creek and Gifford Creek, accepting that upgrades to existing crossings will be required,
- native vegetation clearing is to be kept to a minimum, and

- the Traditional Owners be re-consulted when the location of the proposed tailings storage facilities have been finalized, and that the TSFs be actively managed in order to ensure that they do not contaminate or pollute any natural waterways (Brad Goode and Associates, 2016).

Hastings will commission further Aboriginal heritage surveys with the Thin-Mah Warianga Tharrikari Jiwarli traditional owners.



SCALE: 1:150,000 @ A4

COORDINATE SYSTEM: GDA 1994 MGA ZONE 50
PROJECTION: TRANSVERSE MERCATOR
DATUM: GDA 1994
UNITS: METER

DATA SOURCES:
TOPOGRAPHIC LAYERS: GEOSCIENCE AUSTRALIA
SERVICE LAYERS: GEOSCIENCE AUSTRALIA

ecoscape

PROJECT NO: 3402-15

REV	AUTHOR	APPROVED	DATE
0	JN	ERR	17/01/2017

N

0 1 2 3 4 km

HERITAGE SURVEY AREA AND DEVELOPMENT ENVELOPE

YANGIBANA RARE EARTHS PROJECT

CLIENT: HASTINGS

FIGURE 13

<u>NOISE</u>

Potential sensitive receptors are the accommodation village (an internal receptor not subject to regulation criteria), Edmund Station (homestead) and Gifford Creek Station (homestead) (Herring Storer Acoustics 2016; Appendix 8-3). There are other station homesteads, however these are a significant distance from the proposed operation and will not be impacted by noise emissions from the proposed operation.

Existing background noise at remote locations may be as low as 20 dB(A) for periods when winds are calm and insect noise is not significant. However, background noise typically varies between 25 and 40 dB(A) from:

- wind induced noise from trees planted around sensitive receptors, and
- infrastructure around sensitive receptors that generate noise e.g. power generators, pumps, air conditioning.

The background noise from the natural environment will vary depending on climatic conditions and seasonal insect activity.

<u>DUST</u>

The key sensitive receptor located closest to the operations was identified as the accommodation facility.

6.5.4 Potential impacts

Potential impacts include:

- Direct impacts to visual amenity.
- Indirect impacts to significant heritage sites associated with the Lyons River.
- Direct impacts to significant heritage sites within the development envelope.
- Dust and noise impacts to sensitive receptors.
- Air-blast overpressure noise emissions.
- Mining noise emissions.

6.5.5 Assessment of impacts

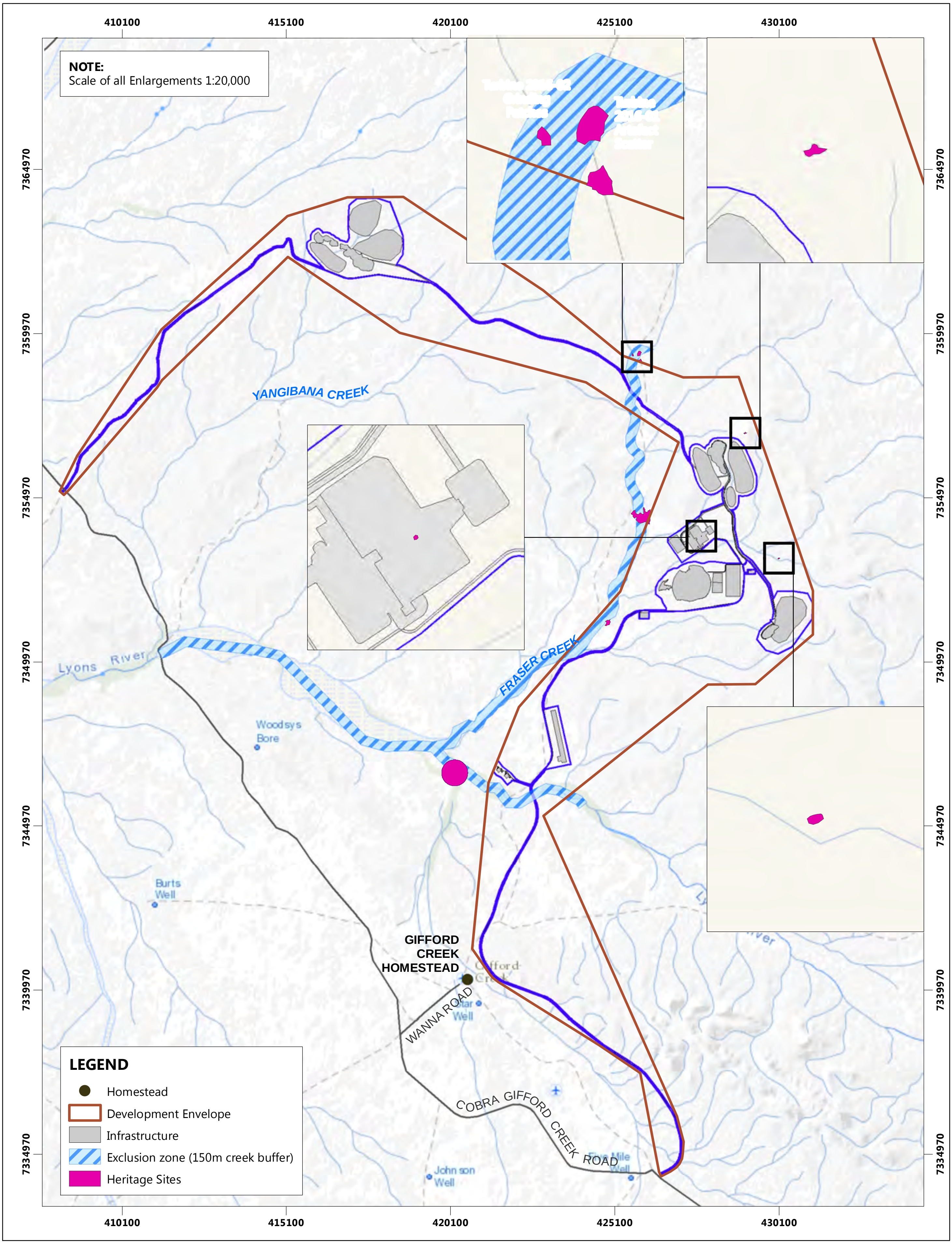
<u>VISUAL AMENITY</u>

The results of the visual impact assessment indicate that relatively small proportions of the proposal's infrastructure will be visible from public roads and the surrounding stations. The proposal will not be visible from Cobra Station. The proposal will be visible from Mount Augustus. Given the proposal is up to 80 km from the Mt Augustus view point, this is regarded as having minimal visual impact.

<u>ABORIGINAL HERITAGE</u>

Several Aboriginal heritage sites occur within the development envelope or in the near vicinity. **Figure 14** shows the locations of each site in relation to the development envelope and the indicative footprint. None of the above-listed sites will be impacted by the indicative disturbance footprint. One site within the processing plant area will be avoided through design of the processing plant. River crossings may require Section 18 of the *Aboriginal Heritage Act 1972* approval prior to disturbance.

There is the potential for direct and indirect impacts to these sites without mitigation.



SCALE: 1:150,000 @ A4

COORDINATE SYSTEM: GDA 1994 MGA ZONE 50
PROJECTION: TRANSVERSE MERCATOR
DATUM: GDA 1994
UNITS: METER

DATA SOURCES:
TOPOGRAPHIC LAYERS: GEOSCIENCE AUSTRALIA
SERVICE LAYERS: GEOSCIENCE AUSTRALIA

ecoscape

PROJECT NO: 3402-15

REV	AUTHOR	APPROVED	DATE
0	JN	ERR	17/01/2017

N

0 1 2 3 4 km

HERITAGE SITES OF THE PROPOSAL

YANGIBANA RARE EARTHS PROJECT

CLIENT: HASTINGS

FIGURE 14

<u>NOISE</u>

Blasting is potentially the most significant operation with respect to noise impact. The distances to receptors are such that ground vibration will not be significant.

Airblast overpressure has been predicted for each of the existing and for the future deposits for standard blast charge of 1000 Kg Maximum Instantaneous Charge (MIC). The predictions under a worst case scenario are that airblast overpressure levels will be significantly below the normal regulation criteria of 115 dBZ peak at the sensitive receptors. A future mining area has also been considered but does not form a component of the proposal and thus not considered here.

The predicted noise levels (worst case maximum) for mining activities are:

- 24 dB(A) at the village (does not exceed criteria of 50 dB(A))
- 13 dB(A) at the Edmund Station homestead (does not exceed criteria of 30 dB(A))
- 18 dB(A) at the Gifford Creek Station homestead (does not exceed criteria of 30 dB(A))

The modelling is considered to be conservative because in practise not all of the mobile fleet will be operating at any one time due to servicing requirements and wait time for either the excavation or the transport equipment.

<u>DUST</u>

The construction phase is expected to produce dust emissions as a result of earthworks although this will be temporary and localised.

During on-going operations activities, the largest dust generation activity will be from wheel generated dust at 462,040 kg/year (PM_{10}), followed by loading (195,302 kg/yr) and unloading (68,872 kg/yr).

The maximum 24-hour TSP, PM10 and PM2.5 concentrations (including background) can be expected to be within the DER criteria at the accommodation facility. It is noted that the background concentration adopted is highly conservative and given the remoteness of the proposal, the background levels can be expected to be less than that used in the assessment.

6.5.6 Mitigation

Hastings commits to the following mitigation of potential impacts:

<u>AVOIDANCE</u>

- A 150 m exclusion buffer will be placed on both sides of Lyons River, Fraser Creek and Gifford Creek, at the request of the Traditional Owners, except where linear infrastructure crosses these water courses (Figure 12).
- A 90 m buffer of Bald Hill waste rock landform and the nearest heritage site.
- Avoid impact to heritage sites by relocating/rearranging position of infrastructure (i.e. processing plant).

<u>MINIMISATION</u>

- Access road has been relocated to minimise noise and dust impacts to Gifford Creek Station (prior to assessment, in consultation with pastoralist).

<u>MANAGEMENT</u>

- Cultural Heritage Management Plan (draft; Appendix 8-2)
- Land Management Plan (to be developed) will include requirements for:

- water sprays to control dust generation from vehicle movements;
- visual monitoring of dust generation; and
- contingency measures for excessive dust generation.

6.5.7 Predicted outcome

With mitigation, the Proposal will meet the EPAs objective for the environmental factor, social surroundings:

To protect social surroundings from significant harm.

7 MATTERS OF NATIONAL ENVIRONMENTAL SIGNIFICANCE

7.1 RELEVANT POLICY AND GUIDANCE

Laws and regulations relevant to the consideration of Matters of National Environmental Significance include:

Environment Protection and Biodiversity Conservation Act 1999 (C'th; EPBC Act)

EPBC Regulations 2000 (C'th)

Relevant guidelines include:

DEWHA (2009) Matters of National Environmental Significance. Significant impact guidelines 1.1 - Environment Protection and Biodiversity Conservation Act 1999

The *Environment Protection and Biodiversity Conservation Act 1999* (C'th; EPBC Act) provides for the protection of nationally and internationally significant flora, fauna, ecological communities and heritage places. Under the EPBC Act, the potential to significantly impact the following Matters of National Environmental Significance (MNES) trigger the requirement for assessment as a 'controlled action':

- World heritage properties;
- National heritage places;
- Wetlands of international importance (listed under the RAMSAR Convention)
- Listed threatened species and ecological communities;
- Migratory species protected under international agreements;
- Commonwealth marine areas;
- The Great Barrier Reef Marine Park;
- A water resource, in relation to coal seam gas or coal mining; and
- Nuclear actions (including uranium mines).

The proposal has been referred to the Department of the Environment and Energy. A reference number has been assigned: 2016/7845.

7.2 EXISTING ENVIRONMENTAL VALUES

7.2.1 World Heritage Property

The Proposal is located over 300 km from the closest World Heritage Property at Shark Bay near Denham, Western Australia. No impact to a World Heritage Property is expected.

7.2.2 National Heritage Places

The Proposal is located over 300 km from the closest National Heritage Place at Shark Bay near Denham, Western Australia. No impact to a National Heritage Place is expected.

7.2.3 Wetlands of International Importance

The Proposal is located over 600 km from the closest Wetland of International Importance at Eighty Mile Beach, Western Australia. No impact to a Wetland of International Importance is expected.

7.2.4 Listed threatened species and ecological communities

Biological assessments included desktop studies and field surveys, completed over the broader Yangibana tenement area (55,000 Ha) referred to as the “study area” (Figure 3), which encompassed and extended beyond the proposed development envelope of 12,098 Ha.

An EPBC Act Protected Matters search, conducted in February 2015 and November 2016 for the study area with a 30 km buffer, reported: One terrestrial flora species (*Pityrodia augustensis*) and five terrestrial fauna species including three mammals (Northern Quoll, *Dasyurus hallucatus*; Ghost Bat, *Macroderma gigas*; Pilbara Leaf-nosed Bat, *Rhinonicteris aurantia* (Pilbara form)), and two birds (Curlew Sandpiper, *Calidris ferruginea*; Night Parrot *Pezoporus occidentalis*). The EPBC listed (Vulnerable) Yinnetharra Rock Dragon (*Ctenophorus yinnietharra*) was not reported on the Protected Matters search, however it was recorded on the WA Department of Parks and Wildlife (DPaW) database search, and for completeness is discussed in this section.

FLORA AND VEGETATION

Despite extensive survey efforts, no threatened flora species listed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) were found within the study area (Ecoscape 2016; Appendix 1).

It is considered highly unlikely that the proposed action will have a significant impact on threatened flora species or threatened ecological communities.

FAUNA

No threatened fauna species listed under the EPBC Act were found within the study area (Ecoscape 2016; Appendix 2).

It is considered highly unlikely that the proposed action will have a significant impact on threatened fauna species or their habitat.

THREATENED ECOLOGICAL COMMUNITIES

No nationally listed Threatened Ecological Communities exist within the footprint of the proposed action (Ecoscape 2016; Appendix 1).

7.2.5 Migratory species protected under international agreements

The EPBC Act Protected Matters search identified six migratory bird species as potentially occurring within the study area:

- Fork-tailed Swift (*Apus pacificus*);
- Barn Swallow (*Hirundo rustica*);
- Grey Wagtail (*Motacilla cinereal*);
- Yellow Wagtail (*Motacilla flava*);
- Curlew Sandpiper (*Calidris ferruginea*); and
- Oriental Plover (*Charadrius veredus*).

None of these species were recorded during surveys. Following further considerations of each species habitat requirements and habits, it was determined that the Proposal was highly unlikely to have any impact on these species (Ecoscape 2016a; Appendix 2).

7.2.6 Commonwealth marine areas

The proposal does not occur within a Commonwealth marine area.

7.2.7 The Great Barrier Reef Marine Park

The proposal does not occur within the Great Barrier Reef Marine Park.

7.2.8 A water resource, in relation to coal seam gas or coal mining

The Proposal does not involve development of coal seam gas or coal mining.

7.2.9 Nuclear actions

As defined in clause 22(1)(e) of the EPBC Act and clauses 2.02(1)(c) and 2.02(2) of the EPBC Regulations 2000 (Cwth), the Proposal may be considered a nuclear action due to TSF2 and TSF3 being considered "large scale facilities for the disposal of radioactive waste". It is noted that the original intent of s22 of the EPBC Act was to consider uranium mining and other nuclear related activities. It was not necessarily intended for non-uranium mining such as mineral sands and rare earth projects.

The Proposal will process ore that contains naturally occurring uranium (U) and thorium (Th) with average concentrations of 27 parts per million (ppm) and 450 ppm, respectively. The ore is defined as radioactive material as it contains radionuclides above 1 Bq/g. Consequently, three studies have been undertaken:

1. Baseline Radiation Report (RadPro 2016a, Appendix 5-4)
2. Radiation Waste Characterisation Report (RadPro 2016b, Appendix 5-5)
3. Radiation Impact Assessment Report (JRHC Enterprises 2016; Appendix 5-6)

The studies show that radiological impacts of the Proposal are very low.

The waste characterisation study reports that radionuclides concentrate in different process streams, particularly the beneficiation regrind and flotation circuit, and the hydrometallurgical circuit. Tailings will be disposed into three distinct TSFs, each with different U and Th concentration ratios relative to the ore. Tailings in TSF1 will be <1 Bq/g. TSF2 and TSF3 will have average activities of 7 Bq/g and 24 Bq/g, respectively. They represent less than 9% of the tailings generated by the ore processing plant. TSF2 and TSF3 will, however, trigger the "nuclear action" criteria specified in the EPBC Act.

7.3 POTENTIAL IMPACTS

Based on environmental studies conducted to-date, there will be no potential impacts to Matters of National Environmental Significance protected by the EPBC Act, including:

- Listed threatened species and ecological communities;
- Listed migratory species;
- Wetlands of international importance;
- The Commonwealth marine environment;
- World Heritage properties; and
- National Heritage places.

Hastings has a high level of confidence that this conclusion will be met.

The proposal is defined as a "nuclear action" under the EPBC Act due to the establishment and operation of TSF2 and TSF3, which will be used for the disposal of tailings from the processing plant cleaner circuit and hydrometallurgical circuit, respectively. Potential impacts to the public, the surrounding environment and the workforce have been assessed:

- Public: Gifford Creek and Edmund homesteads may be potentially exposed to dust and radon/thoron gas.
- Environment: The risks to the surrounding environment include:
  - Seepage of leachable heavy metals and contaminants from the tailings storage facilities;
  - Dust generation at ROM pad, processing plant and TSFs;
  - Contaminated surface water; and
  - Long-term TSF integrity following decommissioning and closure.
- Workforce: The main pathways for potential exposure/impacts to the workforce were identified as:
  - Gamma exposure from material in the mining area, concentrate and TSF3 waste streams; and
  - Dust inhalation from airborne (dry) material from concentrate and TSF3 waste streams.

While dust is a recurrent theme for the public, environment and workforce, it should be noted that the processing plant will operate as a 'wet' process, and tailings deposited in TSF 2 and 3 will be maintained as a 'wet' facility in the operations phase.

7.4 Environmental factor assessment

The relevant environmental factors to be considered include:

- Terrestrial Environmental Quality.
- Inland Waters Environmental Quality.
- Human Health.

Environmental impact assessments have been considered for these key factors in sections 5.4, 5.5 and 5.6.

7.5 Mitigation

Hastings has considered the potential risks and impacts as a result of the proposal. In doing so, Hastings has:

- Conducted baseline studies (Appendix 5-4);
- Conducted waste characterisation studies (Appendix 5-5);
- Conducted an impact assessment (Appendix 5-6);
- Conducted an environmental risk assessment for the Proposal, including impacts to environmental receptors from the presence of TSF2 and TSF3; and
- Developed measures to mitigate these risks to as low as reasonably acceptable (ALARA).

Hastings has a high level of confidence that radiological impacts will be low. Management measures to ensure this outcome are:

- Radiation Waste Management Plan (Appendix 5-7);
- Radiation Management Plan (Appendix 5-8); and
- Preliminary Mine Closure Plan (Appendix 6).

An Environmental Management System (EMS) and Safety Management System (SMS) will be implemented to manage all environmental and safety aspects of the Proposal. The above-listed

Management Plans relevant to the proposed nuclear action with form a component of the EMS and SMS.

8 Holistic impact assessment

The greatest benefit of this Project is its contribution to a more sustainable energy market and progress in medical technologies (amongst other technologies and innovations), which plays a key role in satisfying the principle of intergenerational equity.

A thorough understanding of the surrounding environment has been achieved with baseline studies of:

- Flora and vegetation
- Fauna, including vertebrates, short range endemic fauna and subterranean fauna
- Groundwater
- Surface water
- Waste, including AMD and radionuclide assessments
- Soils
- Baseline radiation assessment (air, soil, water)
- Air quality, including dust and greenhouse gas emissions
- Noise
- Visual amenity
- Heritage

A direct impact to flora and vegetation will occur as a result of ground disturbance (approximately 1000 Ha). This also represents potential fauna habitat. Surveys have shown that all flora and fauna species, vegetation types and habitat are well represented outside of the development envelope and thus the proposal satisfies the EPAs objectives for these environmental factors:

- Flora and vegetation: *To protect flora and vegetation so that biological diversity and ecological integrity are maintained.*
- Fauna: *To protect terrestrial fauna so that biological diversity and ecological integrity are maintained.*

Subterranean fauna species were found within the pit footprint. Further consideration of their interconnections with the broader Gifford Creek Priority Ecological Community (the PEC) instigated a regional survey to determine the representation of species outside of the footprint. A greater diversity and species richness was shown to occur in the PEC outside of the Proposal thus demonstrating the direct impacts to the subterranean fauna would not compromise the biological diversity of the ecological community.

Groundwater assessments included the characterisation of aquifers associated with the proposed mine pit and their interconnectivity with the shallow calcrete aquifer network of the PEC. The fractured rock aquifers associated with the proposed pit dewatering activities were shown to have no interconnection with the calcrete aquifers of the PEC. Consideration of potential impacts from water drawdown associated with pit dewatering activities was also undertaken. A restricted water drawdown impact, associated with the fractured rock aquifers within the pit footprints, also confirmed the lack of connectivity with the PEC habitat and demonstrated this would have no impact on the ecological integrity of the PEC. As such the principle of the conservation of biological diversity and ecological integrity was applied and meets the EPA’s objective:

- Subterranean fauna: *To protect subterranean fauna so that biological diversity and ecological integrity are maintained.*

The PEC is also closely associated with the Lyons River, pastoral bores and Aboriginal heritage values of the Lyons River. Concerns of groundwater contamination associated with the geochemical nature of the tailings were raised during consultation with pastoralists and traditional owners. Characterisation of tailings waste revealed that two of the tailings streams will have elevated radionuclides. Design and management of the tailings storage facilities will ensure risk of groundwater (as well as land and air quality) contamination is mitigated (as described in the Radiation Waste Management Plan). Human health was also considered as a result of the naturally occurring radionuclides and the concentration of these in the processing plant. Mitigation of potential impacts will ensure the EPA's objectives are met:

- Terrestrial Environmental Quality: *To maintain the quality of land and soils so that environmental values are protected.*
- Inland Waters Environmental Quality: *To maintain the quality of groundwater and surface water so that environmental values are protected.*
- Human Health: *To protect human health from significant harm.*

Impacts associated with waste management have been considered more broadly. The polluter pays principle has been applied to ensure Hastings bears the cost of containment and encapsulation of tailings with elevated radionuclides in accordance with relevant policy and guidelines. The principle of waste minimisation has been and will continue to be applied to minimise the generation of waste. Waste management (i.e. waste rock landforms and tailings storage facilities) is also a key consideration in the closure phase of the proposal. As such, a Preliminary Mine Closure Plan will be further developed in consultation with relevant stakeholders (including the EPA and DMP).

The consideration of risks associated with implementing the proposal against environmental factors have been assessed (sections 4 and 5). A conservative approach has been taken to determine the management of potential risks to the environment. As such the precautionary principle has been applied and will continue through the implementation of an Environmental Management System (aligned with the international standard ISO 14001) during construction, operations and closure phases of the proposal.

Review of risks, identification of information gaps where there is a lack of full scientific certainty and application of the precautionary principle will be on-going throughout the life of the proposal, including closure. Management plans will therefore remain dynamic and will be reviewed annually to ensure the continual improvement of management performance in meeting environmental objectives (goals) and targets.

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10 APPENDICES

FLORA AND VEGETATION

Appendix 1-1 Flora and Vegetation Assessment (Ecoscape 2015)

Appendix 1-2 Flora and Fauna Memo: Access Road (Ecoscape 2017)

Appendix 1-3 GDE Memo (Ecoscape 2017)

TERRESTRIAL FAUNA

Appendix 2 Terrestrial Fauna (Ecoscape 2016a)

SUBTERRANEAN FAUNA

Appendix 3-1 Subterranean Fauna Assessment (Ecoscape 2016b)

Appendix 3-2 Regional Subterranean Fauna Assessment (Bennelongia 2017)

WATER

Appendix 4-1 Conceptual Hydrogeological Assessment (Global Groundwater 2016)

Appendix 4-2 Hydrogeological Report (GRM 2017)

Appendix 4-3 Surface Water Assessment (JDA 2016)

MATERIALS CHARACTERISATION

Appendix 5-1 Waste Characterisation Report (Trajectory and Graeme Campbell and Associates, 2016)

Appendix 5-2 Soils Assessment (Landloch 2016a)

Appendix 5-3 Preliminary Landform Surface Erodibility Assessment (Landloch 2016b)

Appendix 5-4 Baseline Radiation Report (RadPro 2016a)

Appendix 5-5 Radiation Waste Characterisation Report (RadPro 2016b)

Appendix 5-6 Radiation Impact Assessment (JRHC Enterprises 2016)

Appendix 5-7 Radiation Waste Management Plan

Appendix 5-8 Radiation Management Plan

Appendix 5-9 Tailings Storage Facility Geotechnical Assessment (ATC Williams 2017)

CLOSURE

Appendix 6 Preliminary Mine Closure Plan

AIR QUALITY

Appendix 7-1 Air Quality Assessment (Pacific Environment 2016)

Appendix 7-2 Memo: Radon and thoron modelling (Pacific Environment 2016)

Appendix 7-3 Greenhouse Gas Emissions Assessment (Pacific Environment 2017)

SOCIAL SURROUNDINGS

Appendix 8-1 Visual Impact Assessment (Ecoscape 2016c)

Appendix 8-2 Draft Cultural Heritage Management Plan (Hastings 2017)

Appendix 8-3 Noise Assessment (Herring and Storer Acoustics 2016)