Decision Report

Licensed Premises

Division 3, Part V *Environmental Protection Act 1986*

Licence Number	L9177/2018/1
Licence Holder	Image Resources NL
ACN	063 977 579
File Number	DER2018/001431
Premises	Boonanarring Mineral Sands Mine Wannamal Road West BOONANARRING WA 6503 Legal description – Mining tenements M70/1194 and M70/1311
Date of Report	26 September 2019
Status of Report	Final

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1. Definitions of terms and acronyms

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

Table 1: Definitions

Term	Definition
ACN	Australian Company Number
AHD	Australian Height Datum
ARI	Average Recurrence Interval
ASLP	Australian Standard Leaching Procedure
Category/ Categories/ Cat.	Categories of Prescribed Premises as set out in Schedule 1 of the EP Regulations
CSM	Conceptual Site Model
Decision Report	refers to this document
Delegated Officer	an officer under section 20 of the EP Act
DMIRS	Department of Mines, Industry Regulation and Safety
DWER	Department of Water and Environmental Regulation
EPA	Environmental Protection Authority
EP Act	*Environmental Protection Act 1986* (WA)
EP Regulations	*Environmental Protection Regulations 1987* (WA)
FPP	Feed Preparation Plant
GL	gigalitre
GOS	Groundwater Operating Strategy
HMC	Heavy Mineral Concentrate
Implementation Agreement or Decision	has the same meaning given to that term under the EP Act
Licence Holder	refers to the Licence Holder, as specified at the front of this Decision Report
m^3	cubic metres
mbgl	metres below ground level
Minister	the Minister responsible for the EP Act and associated regulations
Mtpa	million tonnes per annum
MS	Ministerial Statement
Noise Regulations	*Environmental Protection (Noise) Regulations 1997* (WA)
Non-mining waste	means waste (other than mining waste) generated during construction, operation, rehabilitation and decommissioning activities at the Premises
Occupier	has the same meaning given to that term under the EP Act
PER	Public Environmental Review
PM	Particulate Matter
PM_{10}	used to describe particulate matter that is smaller than 10 microns (µm) in diameter
Prescribed Premises	has the same meaning given to that term under the EP Act
Premises	refers to the premises to which this Decision Report applies, as specified at the front of this Decision Report
Primary Activities	as defined in Schedule 2 of the Revised Licence

Representative Assessment Period	has the same meaning given to that term under the Noise Regulations, and is typically set at 4 hours for mineral sands mining operations
Risk Event	As described in *Guidance Statement: Risk Assessment*
ROM	Run of Mine
SPOCAS	Suspended Peroxide Oxidation Combined Acidity and Sulfur
µg/m^3	micrograms per cubic metre
UTL	upper threshold limit
WCP	Wet Concentrator Plant

2. Background

The Premises is a large-scale heavy mineral sands mine located approximately 80 km north of Perth, in the Shire of Gingin. It is currently the only active mining operation for Image Resources (the Licence Holder), however the company is actively exploring its significant landholdings within the North Perth Basin.

The original mining proposal for Boonanarring was formally assessed in 2013 by the Environmental Protection Authority (EPA) at the level of Public Environmental Review (EPA Report 1516). The proposal was approved by Ministerial Statement 981 on 22 August 2014 (refer to section 4.1).

Within an initial mine-life of 5.5 years, mining was planned to commence in late 2014 and be completed by 2019, however the Licence Holder delayed the start of the project due to market conditions. Site construction commenced in March 2018 and were completed by November 2018, with full mining operations commencing in December 2018.

Activities at the Premises comprise heavy mineral extraction via conventional dry mining methods followed by wet gravity separation to produce a heavy mineral concentrate (HMC). Target minerals include zircon, ilmenite and lesser quantities of rutile and leucoxene, which is hosted in a single strandline that parallels the Gingin Scarp that forms the eastern edge of the Swan Coastal Plain.

The Prescribed Premises category that the Licence is subject, as defined in Schedule 1 of the EP Regulations, is described in Table 2.

Table 2: Prescribed Premises Categories

Classification of Premises	Description	Premises throughput
Category 8	Mineral sands mining or processing: premises on which mineral sands ore is mined, screened, separated or otherwise processed.	3,700,000 tonnes per annual period

3. Overview of Premises

The mine operates within mining leases M70/1194 and M70/1311, which are approximately 1,145 ha in total area and comprise several third party freehold lots. It is immediately adjacent to the Brand Highway and the Bartlett's Well and Boonanarring Nature Reserves (Figure 1).

The Boonanarring orebody covers an area approximately 10 km long and up to 700 m wide. The total disturbance area (i.e. the orebody and disturbance areas required for access and mine infrastructure) is approximately 400 ha. A summary of the project is provided in Table 3.

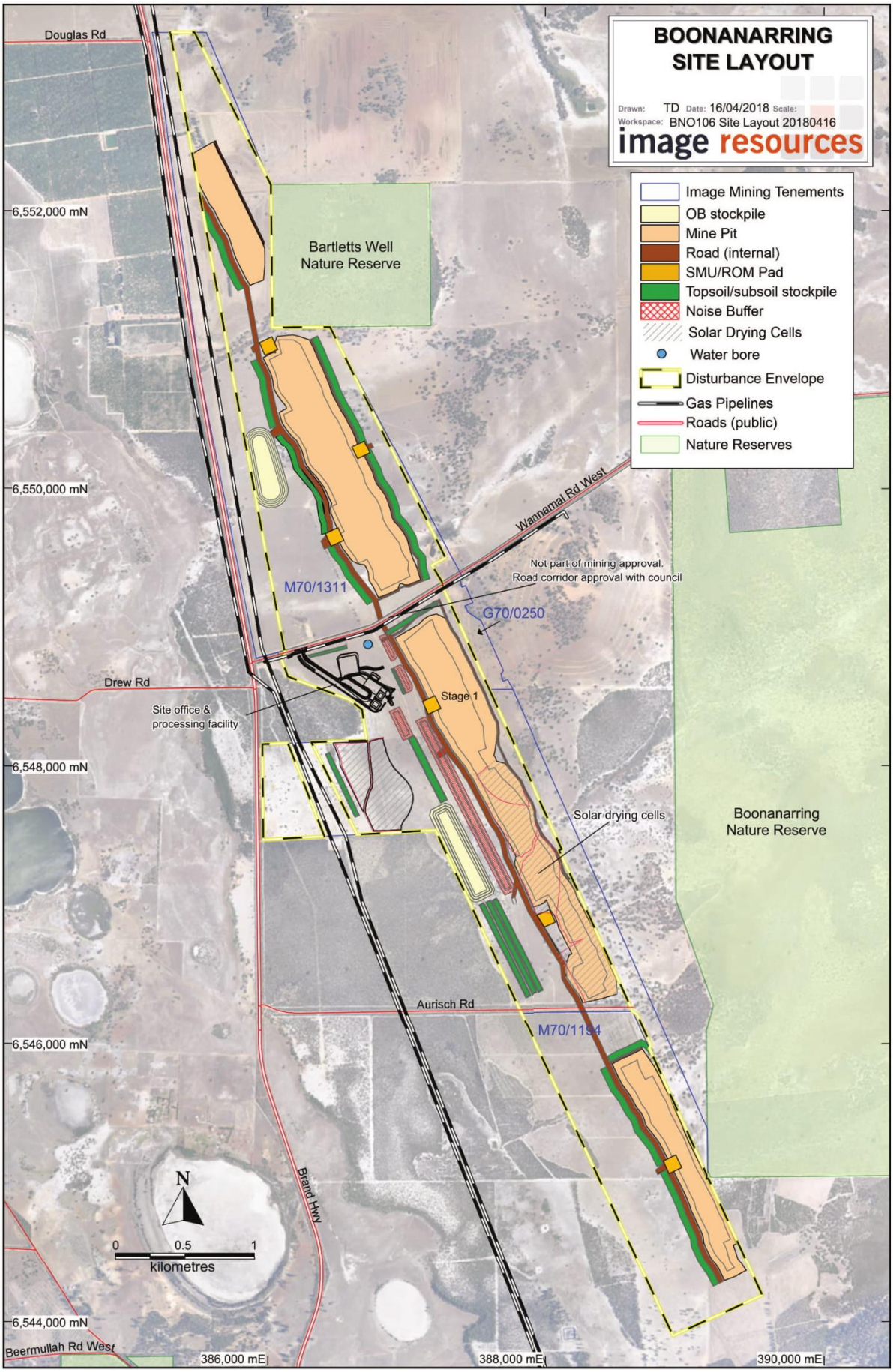

Figure 1: Location and features of the Premises

Table 3: Summary of the Boonanarring Mineral Sands Project

Element	Description
Premises name	Boonanarring Mineral Sands Mine
Mine status	Active
Commodity mined	Mineral sands
Life of mine	6 – 7 years
Land tenure	M70/1194 and M70/1311 are held exclusively by the Licence Holder. The land within the Premises boundary comprises private freehold lots and agreements are in place to allow mining and processing
Ore quantity	19.8 million tonnes at a rate of approximately 3.7 Mtpa
Overburden removed	104.2 million tonnes
Total material disturbed	43.7 million tonnes
HMC recovered	1.1 million tonnes
Pit depth	15 to 60 m below ground level
Area of disturbance	400.0 hectares (within a 1,205 ha disturbance envelope)
Clearing	50.0 hectares
Dewatering	Abstraction of groundwater for dewatering purposes (from the superficial aquifer), to be used in processing
Ore processing	In-pit mining trommel, wet separation plant, flocculant thickener and associated infrastructure to be used to produce a heavy mineral concentrate
Secondary processing	To be conducted off-site at existing mineral separation plants, with sand and clay tailings to be returned to the Premises for backfill to mine voids

3.1 Construction and site development

Construction works commenced in March 2018 and were largely completed by November 2018. The initial site development works involved installation of the main mine access and internal roads and crossings, installation of water supply and management infrastructure, installation of power supply infrastructure and development of the process plant area, including the Wet Concentrator Plant (WCP), thickener and associated infrastructure.

Table 4 provides a summary of the disturbance area by type over the two mining leases.

Table 4: Area of disturbance by mining lease

Disturbance type	Mine activity reference	M70/1311 (ha)	M70/1194 (ha)
Tailings storage facility (class 2)	Off path tails cell	2.0	-
Waste dump or overburden stockpile (class 1)	Temporary waste stockpile north	12.3	-
	Temporary waste stockpile south	13.3	-
	Overburden stockpile/ noise bund	17.0	
Evaporation pond	Solar drying ponds	23.6	-
Plant site	Process plant	11.1	-
Mining void (depth greater than 5m below groundwater)	Pit A (1,800 m x 320 m)	21.0	-
	Pit B (2,950 m x 560 m)	76.0	-
	Pit C (4,500 m x 460 m)	100.0	-

	Pit D (2,500 m x 360 m)	-	39.0
Run of mine pad	ROM pads	5.0	1.0
Miscellaneous mine activities[1]		62.3	16.4
Total tenement area		343.6	56.4
Total mine activity area		**400.0**	

Note 1: Includes fuel storage areas, workshops, stormwater drainage, mining operations area and office, haul and access roads, laydown areas, dewatering/production and monitoring bores, cleared land, topsoil stockpiles.

3.1.1 Pre-production mining and stockpiling

An initial starter pit, 300 m square at the base, was excavated using a truck and excavator fleet within 'Pit C, Stage 1'. A pad for the FPP and ROM (refer to section 3.2.1) was also constructed within the pit and on-mine path, to facilitate start-up, commissioning and mining.

Topsoil and subsoil was initially stripped from Pit C, Stage 1, haul roads, overburden stockpile and the initial solar drying pond (refer to section 3.2.3) areas. Overburden stripped from Pit C, Stage 1 was used to construct noise bunds A, B, C and D. Topsoil and subsoil is currently stored in separate temporary stockpiles to the side of Pit C, Stage 1, for use in rehabilitation. Ore from the pit was pre-mined to basement and stockpiled at the ROM pad.

3.1.2 Commissioning

Commissioning commenced on 12 November 2018 and was completed on 1 December 2018, upon which the mine became operational. Commissioning generally included:

- Hydro-testing of pipelines and pump systems function testing;
- Commissioning of the raw water system;
- Dry commissioning of the FPP, WCP circuit and thickener;
- Wet commissioning of the FPP, WCP circuit and thickener; and
- Commissioning of the process control system.

A total of 88,916 tonnes of ore was used to commission the FFP and WCP circuits and associated equipment, with the heavy mineral concentrate (HMC) produced stored at the HMC stockpile area.

3.2 Operational aspects

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

The HMC (forecast to average around 240,000 tonnes per annum (tpa)) will then undergo secondary processing to produce various grades of zircon concentrates, leucoxene, rutile and primary and secondary ilmenite products. At this stage, secondary processing is planned in China; however should further tenements be developed in the region the Licence Holder has indicated the potential to construct its own mineral separation plant on the Premises.

3.2.1 Mining operations

Full production commenced in December 2018, following the commissioning period. The mine plan involves a five stage approach, with the initial open pit excavation situated immediately east of the process plant and infrastructure area (i.e. south of Wannamal Rd). Mining will then progress south in Pit C, Stage 1, with backfill following the sequence. Around January 2020 mining will then relocate to the north side of Wannamal Rd West and begin in the east side of Pit B and progress north. Once the eastern side of Pit B is mined, Pit A will begin and be mined in conjunction with the west side of Pit B in a southerly direction. Once Pits A & B are complete, mining will recommence in Pit C, Stage 2 and then progress south to Pit D to close out the operation over the six year mine life.

The general sequence of mining operations is outlined below:

- vegetation clearing and topsoil stripping;
- extraction of mineral sands ore using conventional dry mining equipment (e.g. trucks, excavators, dozers and loaders);
- backfilling of sand residues (i.e. clay fines, sand tailings, coarse rejects (oversize), and tailings returned from off-site secondary processing) following mineral processing to either the active mining area (behind the advancing ore extraction area) or solar drying ponds; and
- progressive rehabilitation behind the advancing mining operation.

3.2.2 Ore processing

The mining operation involves excavators and trucks, dozers and loaders to excavate and stockpile mined ore on a run-of-mine (ROM) pad, prior to being fed directly into a loader hopper, consisting of coarse oversize screening, before being transferred to the feed preparation plant (FPP). After removal of coarse oversize and trash, the remaining material reports as 'undersize' and is made into a slurry of approximately 30% solids, and then pumped to the WCP for further concentration.

Slurry from the FPP enters the WCP via a de-sliming circuit comprising a cluster of de-sliming cyclones, followed by a constant density tank (CD tank). Overflow from the cyclones reports through to the thickener, while the underflow goes through to the CD tank, which provides a steady state de-slimed feed to the WCP gravity spiral circuit.

Ore then passes through a series of gravity spirals where the heavy minerals with specific gravities >3.5 flow to the inside of the spirals and separate from the principal waste mineral quartz, which has a specific gravity <3 and travels towards the outside of the spirals. This process recovers the majority of the heavy mineral as HMC, which typically comprises 90 – 95% valuable heavy minerals (principally ilmenite, leucoxene, zircon and lesser amounts of monazite) on a dry weight basis.

HMC concentrate is then pumped to the HMC stockpile area via dewatering cyclone stackers. Cyclone overflow is returned to the process water circuit while the underflow is stockpiled and dried before being transported off-site for sale or further processing. A subsurface drainage system captures stockpile seepage and returns it to the process water circuit.

3.2.3 Tailings management

The tailings streams produced from the WCP will comprise benign sands, clays and heavy minerals (quartz, kaolinite, goethite and ilmenite).

Sand tailings

Sand tailings form the majority of the residues from the WCP which is pumped back to, and deposited in, the mining void using tailings cyclone stackers. During commissioning and the initial stages of mining, there was a requirement to stockpile the sand tailings, until the initial mine void was opened up.

Tailings backfill levels are managed by a combination of reshaping with dozers and moving the cyclone stackers around the mine void, while maintaining adequate freeboard around the void edge, and directing sand tailings as required. The sand tailings are expected to beach at a noticeable angle as water runs off and sand settles out. Water recovered from the tailing slurry is recovered from these areas and recycled back into the process water circuit via in-pit sumps and pumps. Tailings deposition typically follows the mining path and schedule, and mine pits will usually be backfilled within 6 – 8 months.

Clay tailings (clay fines)

Approximately 17% of the tailings material are classed as fines (less than 63 microns), which are typically dominated by the mineral kaolinite and originate mainly from the cyclone overflow at the WCP.

Clay fines are treated in a thickener with flocculants and coagulants, to assist in fines separation. An anionic water-soluble flocculent (e.g. Flopam AN 934 SH) is used for flocculation purposes.

The thickened underflow is then pumped to specially constructed solar drying ponds located on the mine path (also known as “on-path” solar drying cells), and at later stages will be located on top of the backfilled mine void, for drying by solar evaporation.

The clay fines are deposited in the solar drying ponds as a slurry via a pipeline run down the inside face the deposition level and moved around the pond edge. Clay fines will develop a beaching angle away from where it is deposited, as the fines will preferentially settle on the pond floor over time and release contained (supernatant) water to the surface. It was initially proposed that a decant system would be installed on each solar drying pond, to allow collection of supernatant water for recycling back to the process water circuit. The Licence Holder has advised that a pumping system has not been installed to date as no water has needed to be decanted within the first 5 – 6 months of operations, due to the WCP achieving higher densities of clay slimes than expected, and the small amount of water in the solar drying ponds evaporating with no rainfall and hot conditions. The Licence Holder has advised it will install a decant system if it is deemed necessary (i.e. lower densities and therefore higher water content being pumped to the solar drying ponds or during wet season to reclaim rainwater and assist with drying).

The solar drying ponds are shallow (2 m deep) and filled to a depth of approximately 1 m to optimise the drying timeframe, which is estimated between 66 and 196 days, depending on the time of year. After drying, the material will be mixed with the coarse sand tailings and used in the upper layers of the soil profile in preparation for rehabilitation.

Secondary tailings management

HMC is being shipped to China for secondary processing; therefore no tailings from off-site processing are being disposed at the Premises.

Pipeline network

Slurried materials will be transferred around the Premises using high density polyethylene pipelines. The pipelines, which will be in 6 m lengths with flanged sections (butt flanged welded to the end of the line and bolted to a corresponding flange), will be used to transfer the following:

- HMC from the concentrator to the HMC stockpile;
- Clay fines to the solar drying ponds;
- Supernatant water from the solar drying ponds back to the process water pond; and
- Sand tailings to mine pit voids.

Pipelines from the WCP to the FPP and solar drying ponds are located within designated pipeline corridors. The pipeline corridor initially runs directly from the WCP to the FPP and then continues parallel to the mining haul road.

3.2.4 Mine water management

The Boonanarring deposit occurs within the Yoganup Formation, which sits below the Bassendean Sands together with colluvial deposits of the Beermullah Plain (URS, 2013a). It is typically 10 – 20 m thick and occurs between 15 and 60 m below ground level (mbgl).

The Yoganup Formation tends to be partially below the baseline water table (within the Superficial aquifer), which has been interpreted to vary between 68 and 80 m AHD (URS, 2013b). As a result, some dewatering of the open pit mining area is expected to be required, in settings where they extend beneath the water table.

Groundwater inflows will be abstracted temporarily via passive dewatering systems, such as v-drains and in-pit pumps, and recycled for use in the process water circuit to supplement the mine water demand.

As discussed in Section 3.2.3, water also drains from areas within the Premises where partially saturated sand residues and HMC are stored (i.e. solar drying ponds, and tailings and stockpile return water). Where possible, this water will be captured and recycled via the process water pond to supplement the mine water demand.

Table 5 summarises the predicted high-level water balance for the site based on steady state operation. The water balance model will be refined based on actual site experience and seasonal conditions. A conceptual schematic of water inputs and outputs, including operations for obtaining process water is shown in Figure 2 and Figure 3.

3.2.5 Water distribution network

The water distribution network begins by transferring water abstracted from the Yarragadee aquifer via production bores to a series of settling ponds prior to the process water dam, from where it is distributed to processing facilities and associated activities. Water produced from the Superficial aquifer during passive dewatering of the mining void and orebody supplements usage from the Yarragadee. Water systems have been designed to minimise site water usage.

Process water ponds

The process water ponds have been constructed in in-situ material and below the ground surface. There is a bund around the pond that is 1–2 m high and 2–3 m across the top and constructed of compacted clay material. The total pond depth is approximately 6–8 m including the bund. The overall dimensions are around 34 m x 43 m. The floor lining is 1.0 mm HDPE. The design batter angle is approximately 35 degrees.

Table 5: Estimated water balance

Water in	Volume	Water out	Volume
ROM feed	0.37 GL/a	Scrubber oversize stockpile, trommel oversize stockpile, final HMC stockpile	1.74 GL/a
Flocculant			
Attritioner modifier		Coarse tailings water losses to mining void, evaporation and drainage from solar drying ponds, process water pond evaporation, site dust suppression	
Required plant make up water[1]	1.37 GL/a		
Total water in	**1.74 GL/a**	Total water out	**1.74 GL/a**

Note 1: Sourced from Yarragadee production bore and dewatering of the Superficial aquifer.

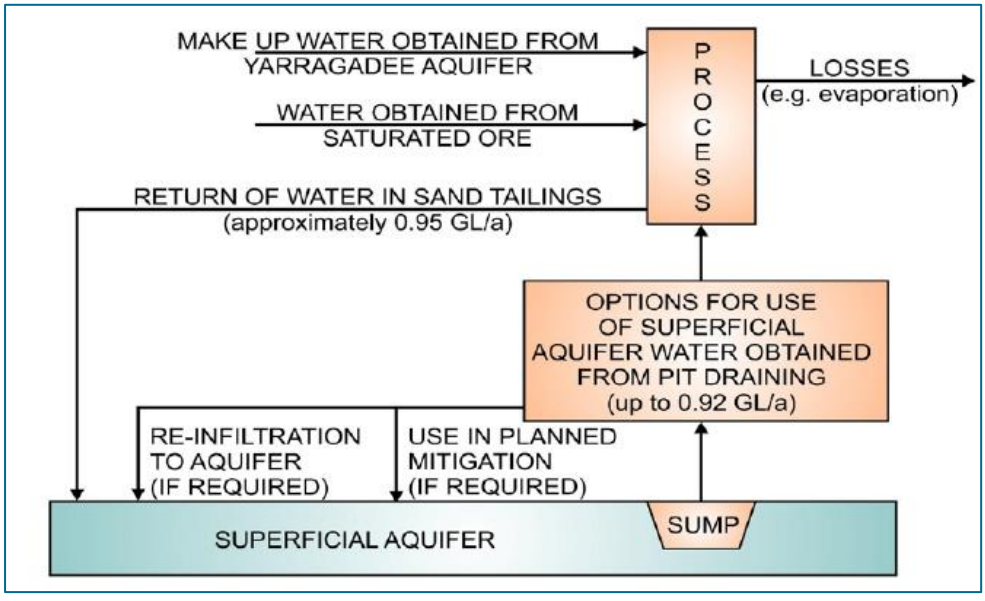

Figure 2: Yarragadee/Superficial aquifers water balance options

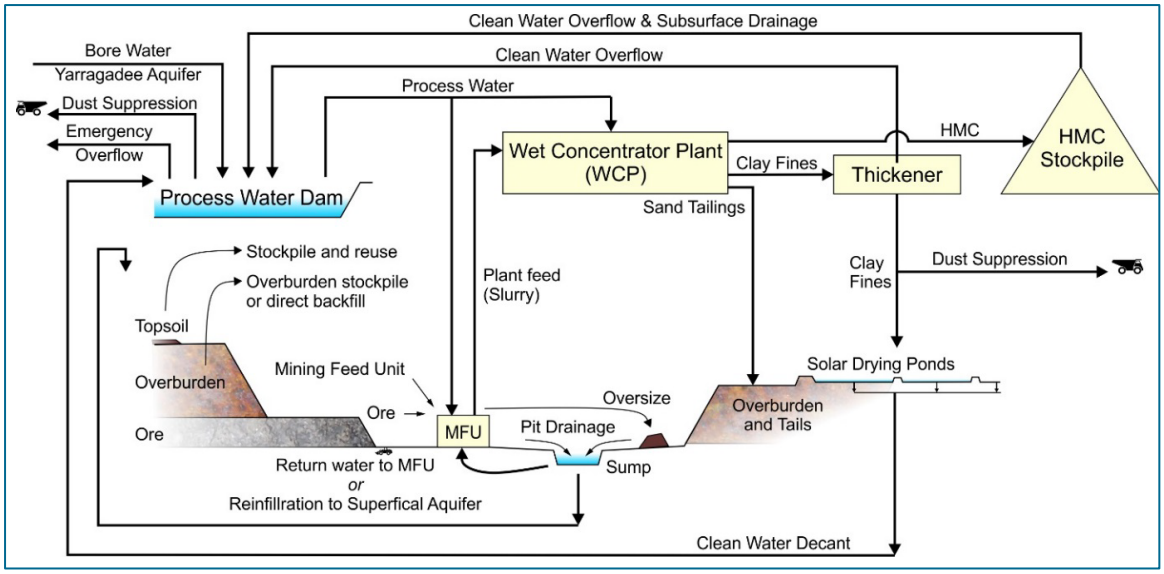

Figure 3: Mine water circuit for the proposed mine

Emergency overflow will flow into the bottom dam and then into a designated area where the water will soak away or be pumped back into the process water circuit.

Stormwater management

Stormwater falling within the mine voids will be captured and directed to in-pit sumps and pumped back to the process water circuit. All stormwater within hardstand areas, such as the WCP and processing area, is diverted to drains and directed towards the process water ponds.

3.3 Infrastructure

The infrastructure at the Premises, as it relates to Category 8 activities, is detailed in Table 6 and with reference to the Site Plan (attached in the Licence).

Table 6: Boonanarring mine infrastructure

Infrastructure	
Prescribed Activity Category 8	
Mineral sands ore is mined using dry mining methods, followed by primary processing using wet separation to produce a heavy mineral concentrate	
1	Excavators and trucks, bulldozers, scrapers and front-end loaders
2	Wet concentrator plant. Includes hydrocyclones and gravity spiral circuits
3	Process water pond (1) and settling dams (2)
4	HMC stockpile (1)
5	Solar drying ponds (7)
6	Mining unit (mobile) and ROM pads (6)
7	Overburden (2) and topsoil/subsoil (7) stockpiles
8	Process water, HMC, tailings and return water distribution network
Directly related activities	
Groundwater abstraction (dewatering) of the Superficial aquifer to allow dry mining conditions, with mine water used to supplement mine water demand	
1	V-drains and in-pit pumps, including water pipelines
Other activities	
1	Groundwater abstraction (Yarragadee aquifer) for processing

3.4 Exclusions to the Premises

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

- contractors' laydown yards, mechanical workshops, equipment storage areas, wash down bay(s), etc.;
- fuel storage and re-fuelling area(s);
- bioremediation area(s); and
- rehabilitation.

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

Key Findings:

1. The Delegated Officer notes the Superficial aquifer is being dewatered to allow dry mining to occur, with the mine water used in processing of ore and with no planned discharges to the environment. On these grounds, the Licence Holder has considered that Category 6: mine dewatering does not apply.
2. The Delegated Officer notes the EPA's assessment of the proposal includes groundwater re-infiltration as a contingency measure to prevent loss or degradation of the defined environmental values within the Bartlett's Well and Boonanarring Nature Reserves.
3. The Delegated Officer considers that any works approval and/or licence issued under Division 3, Part V of the EP Act would not provide a defence against potential offences under the EP Act, such as engaging in conduct affecting the environment (e.g. causing or allowing anything to be discharged, emitted or transmitted) without there being an authorisation in force in relation to it.

4. Legislative context

Table 7: Relevant approvals and tenure

Legislation	Number	Approval
Part IV of the EP Act	MS 981	Ministerial approval for implementation of the proposal (to construct and operate the Boonanarring mine)
Mining Act 1978 (WA)	Registration ID: 67819	Mining Proposal for the Boonanarring Mineral Sands Project (M70/1311, M70/1194)
Rights in Water and Irrigation Act 1914 (WA)	GWL183866(1)	Licensed allocation 99,000 kL/yr from the Gingin Groundwater Area, Perth – Superficial Swan aquifer, for the purpose of dust suppression during mining, earthworks and construction activities The licensed allocation will be increased to 0.92 GL/yr for the purpose outlined above, prior to the commencement of mining
	GWL183864(1)	Licensed allocation 99,000 kL/yr from the Gingin Groundwater Area, Perth – Yarragadee North aquifer, for the purpose of dust suppression during mining, earthworks and construction activities The licensed allocation will be increased to 2 GL/yr for the purpose outlined above, prior to the commencement of mining

4.1 Part IV of the EP Act

4.1.1 Background

The original mine proposal was referred to the EPA in October 2012 under section 38 of the EP Act. A Public Environmental Review (PER) level of assessment was set by the EPA in November 2012, with a five week public review period (EPA Assessment No. 1947).

The Environmental Scoping Document for the assessment was released in April 2013, followed by the PER in January 2014. A total of 11 submissions were received during the public review period, with the key issues raised relating to:

- potential impacts on the nature reserves and adjacent wetlands;
- impacts on sensitive receptors from fugitive dust;
- the proximity of sensitive receptors to the proposal and the predicted noise exceedances at some receptors; and
- radiation risk from mining mineral sands.

The EPA released its final report on the assessment (EPA Report 1516) in June 2014. The Minister subsequently approved the project through the publishing of MS 981 on 22 August 2014.

4.1.2 Ministerial Statement 981 of 2014

The key environmental factors identified in EPA Report 1516 are generally related to the impacts of mining on flora and fauna of conservation significance and on the nearby nature reserves, and hydrological impacts resulting from groundwater drawdown. A number of recommendations were made, however none that were specific to emissions and discharges from the mining operation.

The EPA also provided 'other advice' to the Minister with respect to acid sulfate soils, amenity and mine closure and rehabilitation, noting that other regulatory mechanisms can be used to regulate these aspects.

MS 981 contains a number of conditions that relate to ensuring there are no impacts to native vegetation values and wetlands from dewatering of the Superficial aquifer attributable to mining (including monitoring to demonstrate that any impacts will be contained within the areas predicted, and contingency measures to ensure confidence that values will be protected).

Key finding: The Delegated Officer notes that MS 981 requires the proponent to conduct monitoring of the following themes:

1) the health of native vegetation within the adjacent nature reserves and wetlands; and
2) groundwater levels and quality;

with respect to potential impacts from dewatering drawdown.

Consistent with section 54 of the EP Act:

(4) *If an application for a works approval made under subsection (1) is related to a proposal which has been referred to the Authority under section 38, the CEO shall not perform any duty imposed on him by subsection (3) –*

(b) contrary to, or otherwise that in accordance with, an implementation agreement or decision.

the Delegated Officer has imposed conditions in the Licence for the sampling and annual reporting of groundwater quality in proximity to the mine pits.

4.2 Other relevant approvals

4.2.1 *Mining Act 1978* (WA)

With the exception of land alienated before 1 January 1899, all minerals[1] are the property of the Crown, and a mining title must be obtained from the Department of Mines, Industry Regulation and Safety (DMIRS) before ground disturbing exploration activities or any mining operations may be undertaken (DMP, 2015b).

DMIRS has approved a Mining Proposal (Registration ID: 67819; Preston Consulting, 2018a) to develop the mineral sands deposit on M70/1311 and M70/1194, which is over private land.

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

Mine Closure Plan

All tenements that have an approved Mining Proposal on them must also have an approved Mine Closure Plan (MCP) that has been prepared in accordance with the "Guidelines for Preparing Mine Closure Plans" (DMP, 2015a).

DMIRS has approved a MCP (Registration ID: 74120; Preston Consulting, 2018b) for the project, and has identified minor issues to be addressed in the next MCP revision in 2020 regarding closure obligations, stakeholder consultation and development of completion criteria.

4.2.2 *Rights in Water and Irrigation Act 1914* (WA)

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

The Premises lies within the Gingin Groundwater Area which comprises the Red Gully, Cowalla and Wannamal sub-areas. These sub-areas are fully allocated or over allocated when considering the Superficial, Leederville and Yarragadee aquifer systems, which reflects the high groundwater demand in the vicinity of Gingin and associated competition for the available resources.

Groundwater abstraction in gazetted areas is regulated by DWER under section 5C of the *Rights in Water and Irrigation Act 1914*. It is departmental policy not to issue groundwater licences above allocation limits; however due to the proposed temporary use of the resource DWER has approved the release of an unused allocation that has been reserved for Public Water Supply in the Yarragadee aquifer north of the Premises (Cataby Confined sub-area).

Two temporary section 5C Licenses to Take Water have been issued from the Perth-Yarragadee and Perth-Superficial aquifers (both 99,000 kL/yr) to provide a source of water for initial site works prior to commencement of the operational phase of the project. Licenses based on the Licence Holder's original applications (2 GL/yr from the Perth-Yarragadee aquifer for mining and processing, and 0.92 GL/yr from the Perth-Superficial aquifer for mine dewatering) will be issued for 5 years prior to the commencement of mining.

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

Key finding:

The Delegated Officer notes that DWER's assessment of groundwater abstraction for the Project is based on a limited 5 year mine life modelling scenario, and that any proposal(s) to extend the original mining schedule will require further assessment and approval, in addition to consideration of the competing demands on the water resource.

4.2.3 *Radiation Safety Act 1975* (WA)

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

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

4.2.4 Planning approvals

The Shire of Gingin has advised that planning approvals are not required.

4.3 Part V of the EP Act

4.3.1 Applicable regulations, standards and guidelines

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

The guidance statements which inform this assessment are listed in Appendix 1.

4.3.2 Works Approval and Licence history

Table 8: Works Approval and Licence history

Instrument	Issued	Nature and extent of works approval, licence or amendment
W6065/2017/1	30/10/2017	Works approval for initial site construction and establishment works
W6065/2018/1	26/06/2018	Administrative amendment to correct unintentional errors.
W6065/2018/1	19/10/2018	Amendment Notice 1 – changes to noise controls following updated noise modelling after the Licence Holder purchased the two closest receptors.
L9177/2018/1	27/11/2018	First operating licence for full mining operations.
L9177/2018/1	16/08/2019	Refer to section 4.3.3 below.
L9177/2018/1	26/09/2019	Refer to section 4.3.4 below.

4.3.3 Amendment August 2019

The Licence Holder submitted an amendment application for the following:

- authorisation for on-site disposal of inert waste and used tyres within the mine void;
- removing the requirement to install a decant system on solar drying ponds;
- including provision for co-disposal of clay slimes with sand tailings into mined voids;
- change in the dust monitoring methodology for measuring PM_{10};

- change in ambient groundwater monitoring bores and frequency; and
- update to Schedule 1 maps, to include an additional solar drying pond adjacent to Pit B, change in location of the FPP/ROM pads in Pit B, expansion of 'E dump' overburden stockpile, and an extension of the HMC pad.

4.3.4 Amendment September 2019

The Licence Holder submitted an amendment application following an update to the original noise model for the site, which included modelling for operations in Pit C (Stage 2) and Pit D. The updated model also considered operation of the FPP at natural ground level instead of in-pit (below ground level) for mining in Pit B. The application included the following:

- removing the requirement for the FPP to be operated below natural ground level;
- an increase in the number of haul trucks approved to operate within Pit B during night time overburden removal from 7 to 8;
- approval to operate up to 12 haul trucks within Pit C Stage 2 during night time full production, with 8 operating in-pit and up to 4 at or near surface and with a private agreement in place with receiver J;
- approval to operate up to 9 haul trucks within Pit D during night time overburden removal with a private agreement in place with receiver J.

4.3.5 Clearing of Native Vegetation

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

The EPA has assessed the clearing of remnant vegetation within the areas to be mined and clearing for access. The authorised extent of clearing has been limited to a maximum of 50 ha within a 400 ha disturbance envelope, as described and spatially defined in MS 981.

5. Modelling and monitoring data

5.1 Acid sulfate soils investigation

The Licence Holder has conducted a site investigation (SWC, 2017) to verify whether acid sulfate soils (ASS) are present based on soil characteristics. A total of 840 soil samples from 20 drill holes were taken across the central and southern deposit areas, based on the occurrence of black and dark grey soils recorded in the drilling database, to depths ranging from 27 to 60 mbgl[2].

5.1.1 Results

The key results from the soil sampling and associated analytical testing include:

- in-situ field pH (pH_F) values for all samples tested varied from 4.22 to 7.33. None of the samples tested had a pH_F <4, indicating that actual ASS are unlikely to occur within the deposit;
- oxidised field pH (pH_{FOX}) values for all samples tested varied from 1.97 to 7.44. Approximately 20% of samples had a pH_{FOX} value <4, indicative of potential ASS (PASS). Approximately 5% of all samples tested had a pH_{FOX} value <3, indicative of soils which are likely to contain significant acid production potential;
- a comparison of the results of screen testing (pH_F and pH_{FOX}) with soil colour and texture indicate the majority of soils with low pH_{FOX} values are black or dark grey in colour, had a heavy clay texture and occur either below or at the base of the proposed mining pits (i.e.

[2] Corresponding with the basal contact of the Guildford Formation with the underlying Yoganup Formation, or at the boundary between the Yoganup and underlying Leederville/Yarragadee Formations.

top of the Leederville Formation);
- the results of acid base account analysis, using the SPOCAS (Suspension Peroxide Oxidation – Combined Acidity and Sulfate) testing suite, have shown a strong link between the pH_{FOX} and soil colour/texture of a sample and its potential to hold significant sulfides – this can be useful in effective mine planning to ensure appropriate management tools are in place to mitigate environmental impacts from disturbance; and
- the results of multi-element analysis have shown the samples contain low concentrations of metals and metalloids generally below DWER ecological investigation limits. ASLP leach testing has indicated the release of metals under acidic conditions will be low.

5.1.2 DWER technical review

DWER's review of the *ASS Investigation Report* (SWC, 2017) provided as part of the Application identified that:

- The investigations conducted were carried out in an appropriate staged manner, and the conceptual site model (CSM) developed for determining the distribution of sulfide minerals in the deposit is also considered to be sound and should form a suitable basis for managing the disturbance of sediments during mining;
- The proposed strategy of using the CSM to guide sampling should enable sulfidic materials to be rapidly identified and managed as soon as they are excavated. However, the pH_{FOX} of random samples of sediments with different colours and textures should also be tested periodically on an ongoing basis to ensure that elevated sulfide levels in sediments not identified as being sulfidic by colour or texture in the field can also be detected;
- It is recommended that Total Acidity be included in the monthly groundwater monitoring suite carried out on the site, as it is a more sensitive indicator of groundwater acidification than changes in pH on their own. Trigger values for acidity should also be developed based on the upper threshold limit (UTL) value of background levels in groundwater in the area. Additional sampling should be undertaken where the UTL is triggered, followed by full chemical analysis;
- The frequency of monitoring of pumped effluent from mine dewatering is considered to be too low and will limit the ability of the Licence Holder to rapidly respond to any changes in pH and acidity that occur during dewatering. Field tests of pH, acidity and electrical conductivity should be undertaken at least weekly on the mine dewatering effluent. If trigger levels for these field parameters are exceeded, the dewatering effluent should be resampled and chemically analysed for the full suite of chemical parameters; and
- Contingency measures listed for managing the risk of sulfide oxidation in sediments that contain significant amount of sulfide minerals are suitable. However, only limited information has been provided about how groundwater might be managed in the event that drawdown leads to contamination of groundwater by metals.

Key Findings:

1. Given the relatively low rate of pumping required to dewater the pits, disturbance of ASS should be manageable.
2. Field testing of samples to provide quality control on the effectiveness of the CSM is required to enable sulfidic materials to be rapidly identified and managed as soon as they are excavated. Biannual testing for pH_{FOX} of at least 5 random samples should be conducted to ensure the CSM continues to differentiate between sulfidic and non-sulfidic materials.
3. Weekly field tests for pH, acidity and electrical conductivity should be conducted on the mine dewatering effluent, to enable a rapid response to changes in pH and acidity.

5.2 Noise model

The Licence Holder conducted a noise impact assessment for the project using the noise modelling software *SoundPLAN 7.2*, to predict noise levels at each nearby receiver under a number of operating conditions. The CONCAWE algorithms were selected for the model, as it includes the influence of wind and atmospheric stability (LGA, 2018).

The original noise impact assessment, submitted with the PER in 2013 (LGA, 2013), indicated exceedances of the Noise Regulations at four locations during construction and operation of the proposed mine. Comments received during the public review period of the PER process also expressed concern in relation to noise impacts on sensitive receptors. The model was revised as part of the works approval application and in response to submissions on the PER, to account for equipment and operational changes (LGA, 2017a).

Additional modelling was undertaken to take into account additional noise controls through the use of overburden as noise bunds (LGA, 2017b). An updated model was then submitted as part of the licence application, after the Licence Holder purchased the two closest receptors (D & E), thus removing them as being 'noise sensitive' (LGA, 2018).

September 2019 amendment: An updated model was submitted in August 2019 to firm up requirements for future mining (LGA, 2019). This included the following:

- consideration of 2 additional receptors (located near receptor 'I');
- updated SWL for the FPP based on site measurements;
- Pit B full production noise levels, taking into account the FPP being located at natural ground level and updated pit depths, including one extra haul truck on the surface;
- Pit C Stage 2 full production noise levels; and
- Pit D overburden removal and full production noise levels.

5.2.1 Results

The 2018 model (LGA, 2018), which took into account removal of the two closest receptors, predicted exceedances of the assigned levels at the four closest neighbouring residences (F, G, H & J) during overburden removal and full mining operations during the first three years (excluding Pit C (Stage 2) and Pit D).

During overburden removal, which was originally restricted to daytime hours only but has since been conducted during the evening hours following updates to the model with receptors D & E no longer being noise sensitive, exceedances of up to 1 dB(A) (assuming tonality is not present) were predicted at the two closest receptors (A & F) during the daytime on Sundays and weeknight evening hours under worst-case meteorological conditions. However compliance could be achieved by halving the haul truck fleet under certain weather conditions, which would reduce the overall noise levels by up to 2 dB(A).

During full production (24 hours per day, 7 days per week), exceedances of up to 5 dB(A) were predicted at receptors A, C, F, G, H & J during night-time mining in Pits C, B and A. In order to achieve full compliance, LGA recommended the use of a reduced mining fleet during night time mining in the following:

- Pit C, Stage 1 – no more than 8 haul trucks to be used (mix of CAT 785 and CAT 777), with 4 working in the pit and up to 4 at/near the surface for overburden removal;
- Pit B – no more than 7 haul trucks to be used, with all trucks assumed to be working in the pit area for overburden removal;
- Pit A – no more than 7 haul trucks to be used, with all trucks assumed to be working in the pit area and travelling close to the pit face at all times to maximise noise barrier effects to receptor A; and
- All pits – all excavators to be PC3600, with no more than 2 in use (one in pit, the other near the surface).

Based on the modelling assumptions, compliance with the Noise Regulations could be achieved at all times, i.e. reduced fleet during night-time mining operations. Given the separation distances involves, tonality was not considered to be present in the noise emissions.

The model also took into consideration the use of a series of sizeable noise bunds that vary in height between 13 and 20 m. The modelling indicated that compliance with the Noise Regulations could be achieved in all operational scenarios with these bunds in place.

September 2019 amendment: The latest model (LGA, 2019), which takes into account relocating the FPP from in-pit to natural ground level (west side of the pit, behind Waste Dump G), predicts exceedances of up to 1 dB(A) at the closest receptor (F) during night-time mining in Pit B under worst-case meteorological conditions, i.e. easterly wind conditions. This also assumes a reduced mining fleet (max. 8 haul trucks, with 4 in-pit and up to 4 at/near the surface) and tonality not being present, given the separation distance to nearby receptors (2.5 km). Compliance can be achieved with a reduction of haul trucks operating at the surface during easterly wind conditions.

The latest model (LGA, 2019) also includes mining operations in the southern section of the site (Pit C, Stage 2 & Pit D), which was absent from the original noise models.

The model indicates that as mining progresses south into Pit C (Stage 2 – Halfway), operations will encroach within 1.25 km of receptor J, where exceedances of up to 2 dB(A) are predicted during the weekday daytime period; up to 7 dB(A) during the daytime on Sundays and weeknight evening hours; and up to 12 dB(A) during the night time period. LGA suggests that in order to achieve noise compliance, a series of sizeable noise bunds will need to be constructed, in addition to a significant restriction in mining fleet (may not be feasible). Alternatively, LGA recommends the Licence Holder seek a private agreement with receptor J for the duration of mining in this area.

As mining progresses further south into Pit C (Stage 2 – Southern End), operations will encroach within 500 m of receptor J, where exceedances of up to 8 dB(A) are predicted during the weekday daytime period; 13 dB(A) during the daytime on Sundays and weeknight evening hours; and up to 18 dB(A) during the night time period. LGA indicates that noise compliance is unlikely to be achievable during the Sunday daytime and evening periods and night time periods without significantly restricting the mobile fleet, and therefore recommends the Licence Holder seek a private agreement with receptor J for the duration of mining in this area.

Similar noise compliance issues are predicted as overburden removal and mining progresses into the southern-most Pit D, where operations will still be within 600 – 900 m of receptors J & K. Noise compliance is achievable through construction of a series of sizeable noise bunds in addition to a significant restriction in mining fleet, however LGA's recommendation is for the Licence Holder seek a private agreement with receptor J for the duration of mining in this area.

5.2.2 DWER technical review

DWER's review of the updated *Environmental Noise Assessment* (LGA, 2018) provided as part of the Application identified that:

- The selection of input data and assumptions made are accepted as presenting reliable conclusions on the predicted noise levels and compliance with the assigned levels at noise sensitive receptors under all likely operational scenarios;
- DWER considers that after purchasing the four closest receptors that noise from the project should be able to be managed to comply with the Noise Regulations during overburden removal and full mining operations in Pits A, B & C (Stage 1);
- Minor exceedances are predicted during overburden removal on Sundays and evening time can be readily managed by reducing the number of haul trucks;
- The updated prediction that noise compliance can be achieved during full operation (with reduced haul truck fleet at night) seems reasonable;
- It is noted the haul trucks are the major noise sources in each operational scenario, particularly during overburden removal, and that a sound power level of 118 dB(A) was

used in the noise model for the CAT 777 and CAT 785 haul trucks. SWL measurements conducted on-site in May 2018 (Herring Storer, 2018) indicate the SWL of the CAT 785 haul truck operating at the Premises ranged between 115 and 117 dB(A), therefore the actual noise emission levels may be slightly lower than that predicted in the updated noise model; and

- The Licence Holder has dropped its original commitment to install 'Hushpaks' on haul trucks and excavators as noise mitigation measures, following the updated noise assessment, which DWER considers to be reasonable. However it is noted from the actual SWL assessments conducted on-site in May 2018 there was no discernible difference between the noise levels with/without noise attenuation.

September 2019 amendment: DWER's review of the updated *Environmental Noise Assessment* (LGA, 2019) identified that:

- LGA may have over-estimated the noise reduction from a 20 m high noise bund, which in DWER's experience would be unlikely to achieve up to 18 dB(A) reduction;
- Whilst the proposed additional controls, such as limiting the time of the operation and the use of mobile plant, may be able to further reduce noise emissions from the Premises, they will also likely significantly restrict the Licence Holder's operational capability;
- Sizeable noise bunds (i.e. up to 25 m high) are considered as a major control measure, however these are likely to take considerable time to construct and potentially cause significant noise impacts on the residence the bunds are aiming to protect; and
- As receptor J appears to be the only residence to be affected as operations move into the southern section of the mine, DWER recommends that a private agreement be reached in order for that residence to not be considered 'noise sensitive'. This may include vacating the property or turning it into a caretaker's residence during the mining phase in the area.

Key Findings:

1. Full compliance with the Noise Regulations during overburden removal and full mining operations in Pits A, B and C (Stage 1) is reliant on the implementation of noise controls during specific mining scenarios. These include:
   - Reducing mining fleet during night-time mining;
   - Constructing sizeable noise bunds during specific mining phases;
   - Utilising only one excavator during night-time operations, and working behind the bunds;
   - Continuous, real-time monitoring of noise emissions.
2. Noise compliance will be difficult to achieve during overburden removal and full mining operations in Pit C (Stage 2) and Pit D, without extreme control measures including:
   - Constructing sizeable noise bunds; and
   - Significant reductions in mining fleet during night-time mining.
3. The Licence Holder has advised the following:
   - Due to the proximity of mining to receptor J, additional noise bunds at the southern end of the mine wouldn't fit within the mine boundary;
   - The suggested fleet reductions to achieve noise compliance would be extreme and therefore not feasible; and
   - A private agreement is proposed when mining moves closer to Pit C (Stage 2) and Pit D (around 2021).

6. Consultation

The Works Approval Application was referred to several public authorities and receptors within 5 km of the Premises boundary (listed in Table 10), to which the Delegated Officer considered to have a direct interest in the subject matter of the Application. A summary of the responses is provided in Table 9.

Based on the comments received from referrals during the works approval assessment process, the Delegated Officer considered it unnecessary to refer the licence application.

Table 9: Direct interest stakeholder submissions and DWER consideration

Comment	DWER consideration
Department of Mines, Industry Regulation and Safety	
DMIRS standard mining conditions were applied to the mining tenements and the proponent is required to submit annual environmental reports, in addition to a revised Mine Closure Plan in 2020. DMIRS expects the revised plan will contain more detailed information and a refined closure strategy, and these requirements have been reflected in the final approval document sent to the proponent.	Noted.
Department of Biodiversity, Conservation and Attractions	
The proponent is required under MS 981 to prepare a Nature Reserve Vegetation and Groundwater Monitoring and Response Plan, on the advice of DBCA, to ensure that groundwater dewatering and abstraction associated with the activities does not cause any loss or degradation of defined values within Bartlett's Well and Boonanarring Nature Reserves.	Noted.
Shire of Gingin	
The Shire discussed the proposal at the October 2017 Concept Forum of Councils, in particular the operational aspects brought about by the increase in production rate that will result in an overall noise increase at the 5 and 10 km buffer zones, and the need to protect the immediate sub aquifer and the mine "pull water" only from the Yarragadee aquifer. Council supports DWER in taking a conservative and stringent approach to proposed operational changes to meet acceptable noise levels. Development approval is not required for the proposal.	Noted.
Nearby landowner	
A number of concerns were raised about water supply for the mine and potential impacts on surrounding land owners, in terms of drawdown on existing bores and wetlands in the area. The submitter also raised concerns about noise from operating machinery and reversing beepers, which they experienced during operation of the former Gingin mineral sands mine.	The concerns relating to groundwater abstraction will be considered by DWER as part of the assessment under the RIWI Act. The concerns relating to amenity impacts from noise have been addressed through the imposition of controls on the licence.

7. Location and siting

7.1 Siting context

The Premises is located in the State's coastal Wheatbelt region, on the lower slopes of the Gingin Scarp, approximately 24 km north-west of Gingin and 100 km north of Perth. The Dandaragan Plateau is located to the east of escarpment and the Beermullah Plain to the west.

7.2 Residential and sensitive premises

The distances to identified residential and sensitive receptors are detailed in Table 10.

Table 10: Receptors and distance from activity boundary

Residential and sensitive premises	Distance from Prescribed Premises
Lot 32 on Plan 400196, 120 Douglas Rd, Beermullah (A)	1.8 km north-west of Pit A; 5.3 km north-west of WCP
Lot 404 on Plan 71187, 5297 Brand Hwy, Beermullah (B)*	1.2 km north-west of Pit B; 2.9 km north-west of WCP
Lot 5448 on Plan 206481, 2192 Wannamal West Rd, Boonanarring (C)	2.4 km north-east of Pit B; 2.6 km north-east of Pit C; 3.1 km north-east of WCP
Lot 5447 on Plan 206481, 2402 Wannamal West Rd, Boonanarring (D)*	0.3 km east of Pit C; 1.5 km north-east of WCP
Lot 10 on Diagram 87243, 18 Drew Rd, Beermullah (E)*	1.0 km west of WCP; 1.3 km west of Pits B & C
Lot 11 on Diagram 87243, 116 Drew Rd, Beermullah (F)	2.2 km west of WCP; 2.3 km west of Pit B; 2.5 km west of Pit C
Swan Location 192 4791 Brand Hwy, Beermullah (G)	2.4 km south-west of WCP; 2.6 km south-west of Pit C
Lot 1758 on Plan 114095, 4731 Brand Hwy, Beermullah (I)	2.9 km south-west of Pit C; 3.0 km west of Pit D; 3.4 km south-west of WCP
Lot 5918 on Plan 165282, 275 Aurisch Rd, Boonanarring (J)	0.3 km east of Pit C; 0.4 km north-east of Pit D; 3.1 km south-east of WCP
Lot 1 on Diagram 82561, 175 Highlands Rd, Boonanarring (K)	1.1 km south-east of Pit D 2.9 km south-east of Pit C
Lot 22 on Plan 68417, 536 Nine Mile Swamp Rd, Beermullah (1)	4.5 km west of WCP
Lot 2959 on Plan 143785, 391 Nine Mile Swamp Rd, Beermullah (2)	4.3 km south-west of WCP
Lot 1754 on Plan 104863, Beermullah (3)	5.4 km south-west of WCP
Lot 3123 on Plan 255126, 86 Mayfield Rd, Beermullah (4)	6.2 km south-west of WCP
Lot 13 on Plan 63604, 96 McVee Rd, Beermullah (5)	5.1 km west of Pits C & D
Lot 10 on Diagram 89983,	5.1 km west of Pit D

262 Beermullah Rd, Beermullah (6)	
Lot 2956 on Plan 202657, 54 Nine Mile Swamp Rd, Beermullah (7)	4.1 km west of Pits C & D
Lot 2243 on Plan 124052, 23 White Lake Rd, Beermullah (8)	3.8 km west of Pits C & D
Lot 30 on Plan 65047, 102 Beermullah Rd, Beermullah (9)	3.6 km west of Pits C & D
Lot 31 on Plan 65047, 4523 Brand Hwy, Beermullah (10)	3.4 km south-west of Pit D
Lot 1215 on Plan 250008, 83 Harris Rd, Beermullah (12)	4.6 km south-west of Pit D
Lot 201 on Plan 302098, 4761 Brand Hwy, Beermullah (11)	3.1 km west of Pits C & D
Lot 503 on Plan 59680, 5857 Brand Hwy, Beermullah (13)	4.6 km north of Pit A
Lot 5382 on Plan 206477, 5708 Brand Hwy, Red Gully (14)	5.5 km north of Pit A

*Note: * denotes property has been purchased by the Licence Holder or will be vacant for the period of mining.*

7.3 Physiography

The Premises is defined by the Swan Coastal Plain physiographic unit, which is bounded to the east by the Gingin Scarp and the Indian Ocean to the west.

7.3.1 Regional geology

The Premises is located on the Dandaragan Plateau and Swan Coastal Plain, to the west of the eastern edge of the Swan Coastal Plain, where the footslopes of the Gingin Scarp rise steeply to the Dandaragan Plateau. The local area comprises several surface geology units, however the Premises itself is predominantly located on the sand plain surface geology unit to the east of the Brand Hwy and the Gingin Scarp, and a smaller portion on the Bassendean Sand unit to the west.

The stratigraphic sequences relevant to the Premises include the Quaternary aged Colluvial/Bassendean Sands and Guildford Formation, the Late Tertiary Yoganup Formation and the Mesozoic Leederville and Yarragadee Formations. All of these surficial geological formations have either been formed or have been strongly influenced by marine regression and transgression events since the Early to Mid-Tertiary (approx. 50 million years ago).

The Leederville and Yarragadee Formations, which typically forms the base of mineral sand operations on the Swan Coastal Plain, consists of interbedded, weakly to well consolidated sandstone, siltstone, shale and claystone that, in the upper portions, have been deposited in a non-marine, primarily fluvial setting. The Leederville Formation sediments conformably overlie the Yarragadee Formation. The mineralised sands of the Yoganup Formation unconformably overlie the Mesozoic Formations, and consists primarily of friable ‘beach’ sands which were deposited and developed during successive marine transgression and regression events.

The Yoganup Shorelines remained active for a prolonged period and during that time the surface topography would have resembled the current, present day coast. At the beginning of the Quaternary Period, sea levels regressed, bringing alluvial, fluvial and colluvial conditions which resulted in the deposition of the predominantly clayey Guildford Formation, directly over the shoreline deposits of the Yoganup Formation. Lastly, unconformably overlying the Guildford sandy clay to clay sediments are a series of Aeolian sand dunes belonging to the Bassendean Formation.

7.3.2 Landform and soils

The Premises is located within the Swan Coastal Plain geomorphological division and is situated on the Dandaragan Land System. This system is characterised as a subdued dissected lateritic plateau, with undulating low hills and rises with narrow alluvial plains.

The mineralisation of the Boonanarring deposit is hosted by the Yoganup Formation. The main geological units identified include:

- **Surface sands**: low clay, yellowish coloured and generally unconsolidated sands that occur from surface to depths of 4 – 10 m and which are interpreted as belonging to the Bassendean Sand unit. In some areas, lateritic surface gas formed at the base of this unit;
- **Red cover sands**: red to brown coloured iron-rich sands that have varying levels of induration and which often contain clayey lenses towards the base of the unit. Oversize material is common and goethite/limonite chips can report as heavy mineral concentrates. The sands are often coarse, suggesting a high energy depositional environment, and interpreted to correlate to the Guildford Formation;
- **Host sands**: brown to light grey, fine to medium grained sands that are well sorted and generally increase in grain size towards the base of the unit. This unit is correlated with the Yoganup Formation and contains heavy mineral accumulations associated with strandline deposition.

The heavy minerals within the Yoganup Formation have been concentrated in two main strandlines that coalesce in the south and are continuous over a strike length of 13.2 km. An additional strandline to the west is present in the southern part of the Premises. The basement to the strandline mineralisation is demarcated by the increased slimes content of the clay-rich Leederville Formation (refer to section 7.7).

7.4 Specified ecosystems

Specified ecosystems are areas of high conservation value and special significance that may be impacted as a result of activities at or Emissions and Discharges from the Premises. The distances to specified ecosystems (and other relevant ecosystem values which do not fit the definition of a specified ecosystem) are shown in Table 11.

The table has also been modified to align with the *Guidance Statement: Environmental Siting.*

7.5 Surface hydrology

The Premises is located about midway between the Gingin Brook and the Moore River. At a local scale, the Premises occurs on the Gingin Scarp between Red Gully Creek (to the north) and Boonanarring Creek (to the south). The combined catchment is referred to as the Beermullah Plain Watershed.

In the immediate vicinity of the Premises, the watershed is characterised by a number of small-scale ephemeral drainage lines originating from the western Dandaragan Plateau and upper slopes of the Gingin Scarp. The Bartlett's Well and Boonanarring Nature Reserves occur within this watershed. Elsewhere, the agricultural land uses reflect altered hydrology settings.

Table 11: Environmental values

Specified ecosystems	**Distance from the Premises**
Ramsar Sites in Western Australia	The closest Ramsar sites are the Forrestdale & Thomsons Lakes, located in the southern suburbs of Perth, approx. 100 km south of the Prescribed Premises.
Important wetlands – Western Australia (Environment Australia, 2001)	The closest listed important wetlands include the Wannamal Lake System (approx. 20 km east), Chandala Swamp (approx. 28 km south) and Karakin Lakes (approx. 38 km north-east).
Geomorphic Wetlands	The Premises is located at the toe of the Gingin Scarp and up-hydraulic gradient of the Beermullah Plain, which hosts a number of wetlands (palusplain, sumplands, damplands and lakes). The most prominent is the Mindarra Northwest Wetlands suite, which comprises the Beermullah and White Lakes, Little and Big Bootine Swamps, Yurine Nature Reserve and Collard's wetland (see Section 7.6.1).
Lands and Waters managed by the Department of Biodiversity, Conservation and Attractions	Several nature reserves are located in close proximity to the Premises, including Bartlett's Well Nature Reserve, which adjoins the north-eastern corner of the Premises, and Boonanarring Nature Reserve, located immediately east of the Premises. Other reserves in the vicinity include the Yurine Swamp Nature Reserve (approx. 4 km south-west), Sand Spring Well Nature Reserve, Moore River Nature Reserve and Moore River National Park (approx. 6 km west) and Bootine Nature Reserve (approx. 8 km south-west).
Threatened Ecological Communities and Priority Ecological Communities	The majority of the area within the immediate vicinity of the Premises boundary is mapped as the Banksia Woodlands ecological community, which was listed as 'endangered' under the EPBC Act in 2016. Several areas mapped as the TEC 'Muchea Limestone' (Endangered) are located 3 – 5 km west of the Premises. Several areas mapped as PECs 'SCP07' (Vulnerable), 'SCP22' (P2) and 'SCP23b' (P3) have been recorded in the broader locality.
Biological component	**Distance from the Premises**
Threatened/Priority Flora	A total of 26 rare flora species have been recorded within a 7.5 km radius of the Premises. Three Declared Rare species, *Banksia mimica*, *Goodenia arthotricha* and *Thelymitra dedmaniarum*, and 23 priority species have been identified, primarily within the adjacent Bartlett's Well and Boonanarring Nature Reserves.
Other relevant ecosystem values	**Distance from the Premises**
Hydrography – surface water	The local watershed is characterised by a number of small-scale drainage lines. Red Gully Creek is located approx. 5 km north of the Premises, and Boonanarring Brook is approx. 3 km south (see Section 7.5).
Acid Sulfate Soils Risk map, Swan Coastal Plain	The Premises is mapped as 'moderate to low risk of ASS'.

Typically, the drainage lines are dry, with stream flow limited to periods after heavy rainfall. They are also discrete and disconnected, shedding the local slopes of the escarpment before truncating in outwash settings at the escarpment toe. The underlying soil composition is largely colluvium and undifferentiated sand in the upper catchment, with the lower outwash integrated with Bassendean Sands. The majority of stream flow infiltrates and is not transmitted to the wetlands and lakes of the Beermullah Plain.

The distances to surface water and water sources are listed in Table 12.

Table 12: Surface water and water sources

Surface water and water sources	Distance from Premises	Description and environmental value
Red Gully Creek South	Approx. 2.3 km north-east	A seasonal tributary of Red Gully Creek
Boonanarring Brook	Approx. 4 km south	A seasonal brook originating in the Boonanarring Nature Reserve and terminating at the Beermullah Plain
Whitfield Brook	Approx. 4.5 km west	A seasonal brook on the Beermullah Plain
Red Gully Creek	Approx. 7.5 km north	A seasonal creek system originating on the Gingin Scarp and terminating at the Beermullah Plain
Wallering Brook	Approx. 8 km south	A seasonal tributary of the Gingin Brook. Approx. 40% is covered by nature reserve
Gingin Brook	Approx. 12 km south	A freshwater tributary of Moore River that flows year-round due to springs and groundwater seepage. Classified as 'conservation significant' under the Gingin Surface Water Allocation Plan
Moore River	Approx. 18.5 km north	A major, permanent watercourse that originates in Perenjori and flows through the Gingin Scarp before discharging into the Indian Ocean at Guilderton. Salinity levels vary from brackish to saline

7.6 Wetlands and Groundwater dependent vegetation

7.6.1 Wetlands

No geomorphic wetlands have been mapped within the Premises; however various wetlands in the form of ephemeral or permanent lakes or low-lying swamps are located west of the Brand Hwy, at the toe of the Gingin Scarp and in the depressions on the Beermullah Plain.

Approximately 2 – 3 km west of the Premises lies a chain of conservation category wetlands comprising Beermullah Lake, White Lake, Little and Big Bootine Swamps, and several unnamed water bodies, which together are referred to as the Mindarra Northwest wetlands. Many of these lakes and water bodies are interconnected by seasonal damplands, small creeks and palusplains, and most draw water from both seasonal flow of drainage lines and groundwater expressed at the surface.

7.6.2 Groundwater dependent vegetation

The Licence Holder has mapped areas of potential groundwater dependent vegetation (GDV) in Bartlett's Well Nature Reserve and an area of Boonanarring Nature Reserve adjacent to the proposed mining area, and identified other areas within and outside of the Premises that may be sensitive to changes in groundwater quality and levels (360 Environmental, 2013).

Potential wetland GDV within Bartlett's Well Nature Reserve was mapped in the flow area at the base of the main valley in the reserve, in an area of seasonal groundwater overflow from the perched Mirrabooka Aquifer, and was considered by the Licence Holder to be independent of the Superficial and Leederville aquifers.

Potential terrestrial GDV in the form of *Banksia attenuate – Banksia menziesii* low woodlands occurs in large parts of Boonanarring Nature Reserve and Bartlett's Well Nature Reserve, in areas west of the perched western margin of the Mirrabooka Aquifer. The water table with the greatest elevation west of the Mirrabooka Aquifer is that associated with the Superficial Aquifer at approx. 50 mbgl, which is considered inaccessible to native vegetation. As such, these wetland vegetation units are not considered to be GDV.

7.7 Hydrogeology

The hydrogeology of the Premises is characterised by five major aquifer systems (Figure 4):

- **Surficial Aquifer** – surficial sediments of Neogene and Quaternary period within the Red Gully sub-area. This aquifer is patchy and discontinuously present east of the Brand Hwy;
- **Mirrabooka Aquifer** – surficial formations of the Red Gully sub-area, beneath the Dandaragan Plateau. The Mirrabooka Aquifer lies beneath the Surficial Aquifer and is located east of the Brand Hwy and of the proposed mining footprint;
- **Superficial Aquifer** – superficial formations of the Red Gully and Beermullah Plain sub-areas, thus beneath the Gingin Scarp and Beermullah Plain;
- **Leederville Aquifer** – beneath the surficial formations (Dandaragan Plateau) and superficial formations (Gingin Scarp and Beermullah Plain); and
- **Yarragadee Aquifer** – unconformably underlies the Leederville Aquifer in the area, and separated from the Leederville Aquifer by a clay layer.

7.7.1 Surficial

This aquifer, separate to the deeper Mirrabooka Aquifer, has been identified as a perched aquifer within the Bartlett's Well Nature Reserve. The Surficial Aquifer generally has salinity less than 500 mg/L TDS and is known to support groundwater dependent ecosystems.

7.7.2 Mirrabooka

Beneath the Dandaragan Plateau the surficial Mirrabooka Member, Osborne Formation forms an unconfined aquifer (Mirrabooka Aquifer). This aquifer is not interpreted to underlie the proposed mine pits and therefore will not be intercepted by dewatering activities; however it underlies both the Boonanarring Nature Reserve and Bartlett's Well Nature Reserve.

7.7.3 Superficial

A water table aquifer system (Superficial Aquifer) occurs within the superficial formations beneath the Swan Coastal Plain. Locally, the aquifer system comprises Bassendean Sands, Guildford Clay and the Yoganup and Ascot Formations. The Bassendean Sands and Guildford Clay together with colluvial deposits are predominant beneath the Premises and adjacent settings of the Beermullah Plain. It is interpreted that the Collard's Wetland (west of the Brand Hwy) is supported by a perched aquifer within the Superficial formations and is associated with the Superficial Aquifer.

The proposed open pits of the Project will intersect the superficial formations. It is anticipated groundwater from the unconfined Superficial Aquifer will be abstracted temporarily via passive dewatering systems, such as V-drains and in-pit pumps, before the mine voids are backfilled. No water will be abstracted from the Superficial production bores for operational purposes.

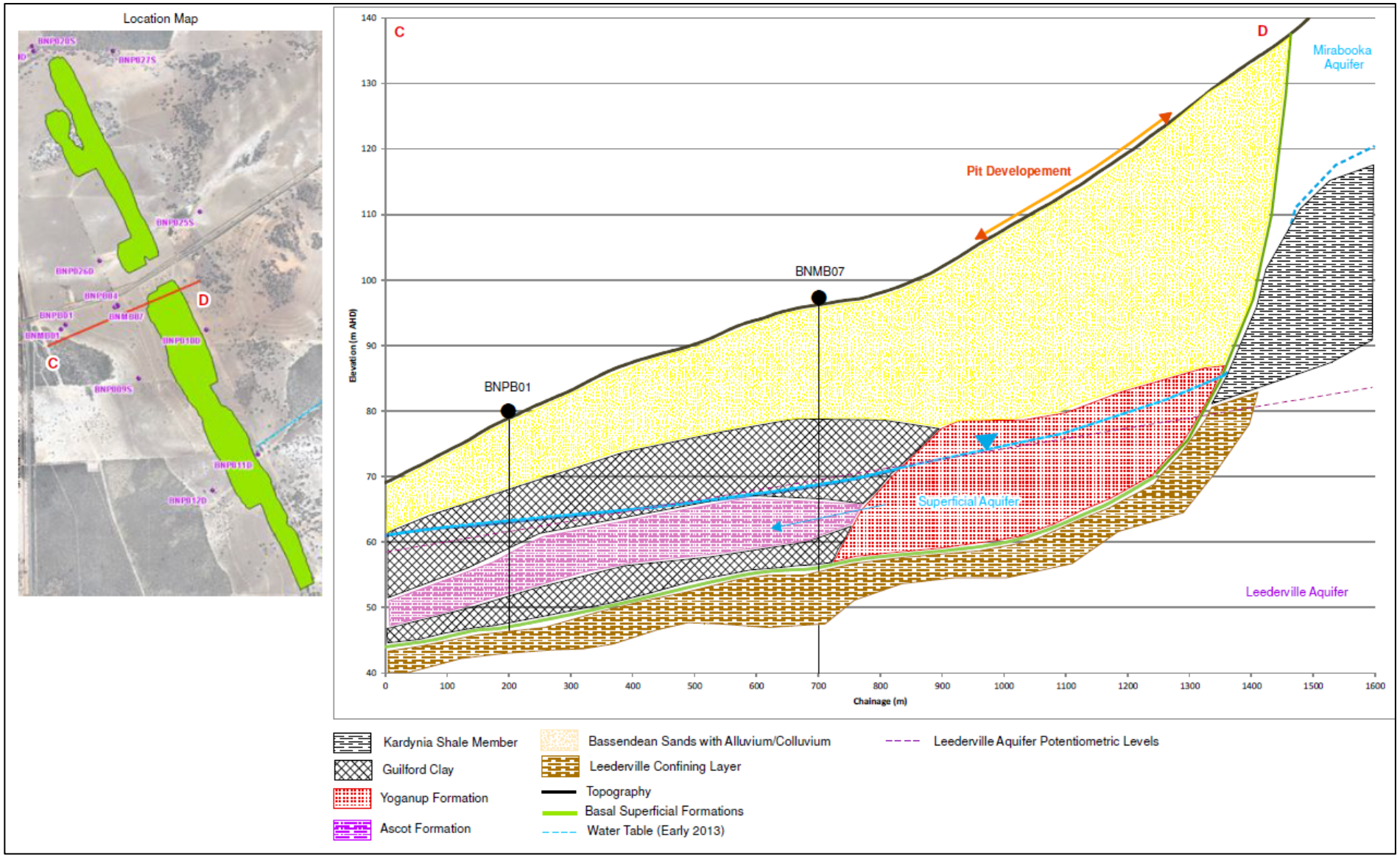

Figure 4: Conceptual local hydrogeology cross-section

7.7.4 Leederville

The Leederville Aquifer is a significant regional multi-layered groundwater flow system comprised of the Pinjar, Wanneroo and Mariginiup members of the Leederville Formation. The Leederville Aquifer is interpreted to be confined by the Kardinya Shale Member of the Osborne Formation beneath the Dandaragan Plateau; however beneath the Swan Coastal Plain, it become semi-confined, supporting the groundwater levels within the superficial formations with upward leakage

7.7.5 Yarragadee

The Yarragadee Aquifer is a regional confined multi-layered groundwater flow system aquifer formed by the Yarragadee Formation and Gage Formation. Locally, the Yarragadee Aquifer successions have a thickness greater than 2,800 m, comprised of interbedded sandstones, siltstones and shales. Within the Premises, the Yarragadee Aquifer is intersected by a production bore, with groundwater intended for use as site process water.

7.7.6 Groundwater occurrence and flow

Beneath the Dandaragan Plateau, a comparatively deep water table occurs associated with the Surficial Aquifer formed by the Mirrabooka Aquifer. Water table elevations range from about 75 to 130 mbgl.

Beneath the Gingin Scarp and Beermullah Plain, the water table is commonly hosted within the Bassendean Sands and Guildford Clay successions. Both the footslopes areas of the escarpment and the Beermullah Plain are characterised by shallow water table environments that support wetlands (including the perennial Beermullah Lake) and potential groundwater dependent ecosystems.

7.7.7 Groundwater quality

Beneath the Premises, groundwater in the Superficial Aquifer is predominantly fresh, though brackish at a local level, with Total Dissolved Solids (TDS) concentrations in the range 97 to 1560 mg/L. Regional data show wider salinity ranges 1,800 to 4,500 mg/L near to the Gingin Brook and Gingin mine project areas. Salinity appears to be influenced by recharge sources, stratigraphy and lithology, and depths to the water table.

Groundwater salinity in the Leederville and Yarragadee aquifers beneath the Premises indicates a sodium-chloride type groundwater, with TDS in the range 570 to 910 mg/L and 1,340 to 1470 mg/L, respectively.

7.8 Native vegetation

The local area falls within the Drummond Botanical Subdistrict of the Darling Botanical District of the South Western Botanical Province. Remnant vegetation of the Premises and surrounds is mainly mapped as comprising the Moondah Complex (low closed forest and low open forest), the Gingin Complex (open woodland) and the Reagan Complex (low open woodland to closed heath).

7.8.1 Flora and vegetation surveys

The disturbance footprint within the Premises has been extensively cleared for agriculture, with small areas of vegetation exhibiting low species richness and vegetation values (360 Environmental, 2013). There are pockets of relatively intact vegetation occurring along the road verges of Aurisch Road and Wannamal Road West and in the Bartlett's Well Nature Reserve access track corridor, and small remnants of scattered paddock trees. As such, flora and vegetation surveys conducted by the Licence Holder have targeted these areas, in addition to potential groundwater-dependent vegetation, particularly in the adjacent nature reserves, that could be indirectly impacted by the project.

Conservation areas

Previous surveys of the area have recorded a total of 222 taxa and a diverse range of vegetation types within Bartlett's Well Nature Reserve, including a small conservation category wetland. A DEC biological survey of Boonanarring Nature Reserve in 1996 recorded a total of 573 taxa and 10 vegetation associations, indicating the reserves have a very high conservation value.

7.9 Physical environment

7.9.1 Climate

Boonanarring is situated within a Mediterranean climate region that is characterised by warm to hot, dry summers and cool, wet winters.

Weather patterns are dominated by the regular passage of rain-bearing cold fronts from the Indian Ocean in winter, and dry easterly air flows from inland areas in summer. Rainfall progressively declines in northerly and easterly directions (i.e. as distance from the coast increases).

7.9.2 Wind direction and strength

The nearest Bureau of Meteorology (BoM) weather station is located at Gingin Aero (Site number 009178), approximately 25 km south of the Premises.

The average wind direction at 9 AM and 3 PM is presented in Figure 5. The following wind roses represent the various percentage of wind occurrences recorded during the period 1996 – 2010 (BOM, 2018). The graphs illustrate predominantly moderate winds from the east in the mornings, shifting to moderate-to-strong afternoon west/south-westerly winds in the summer and winter months, respectively.

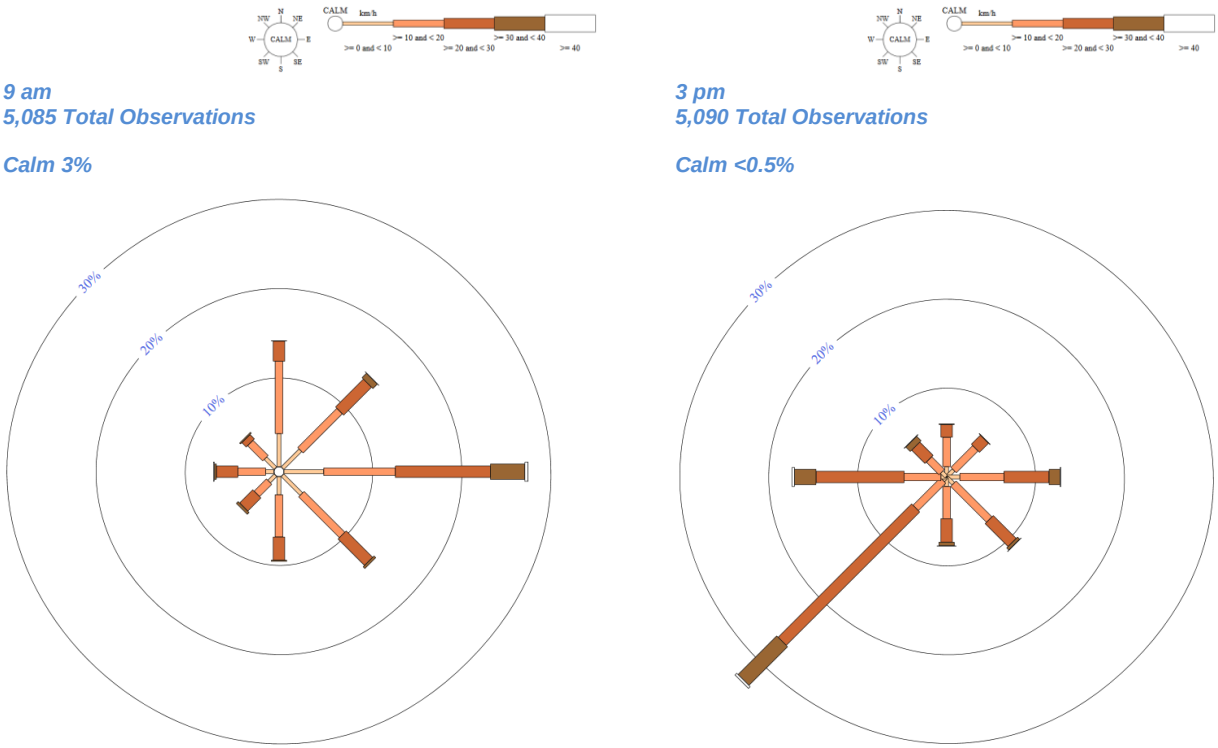

Figure 5: Wind roses, Gingin Aero 1996 – 2010 annual average at 09:00 am and 3:00 pm

7.9.3 Rainfall and temperature

According to the Köppen-Geiger climate classification system, Gingin is considered a hot-summer Mediterranean climate, where there is at least 3 times as much precipitation in the wettest month of winter as in the driest month in summer, and the driest month in summer

receives less than 30 mm. The average temperature is 18.3 °C and annual average rainfall is 632 mm.

BoM (2018) climate records indicate rainfall is the lowest in December, with an average of 9.7 mm. Most of the precipitation falls in July, averaging 126 mm. January and February are the warmest months of the year, with an average of 33.2 °C. July is the coldest month, with temperatures averaging 6.2 °C (Figure 6).

There is a difference of 116 mm of precipitation between the driest and wettest months. Throughout the year, temperatures can vary by 27 °C.

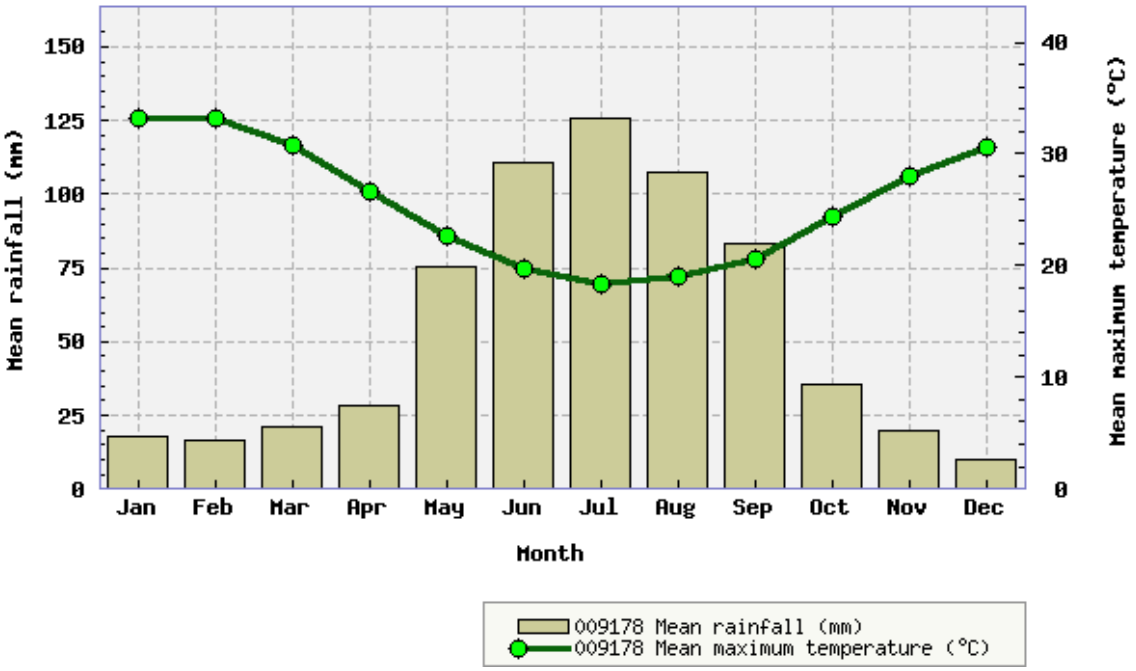

Figure 6: Average rainfall and maximum temperature for Gingin Aero 1996 – 2017

8. Risk assessment

8.1 Determination of emission, pathway and receptor

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

To establish a Risk Event there must be an emission, a receptor which may be exposed to that emission through an identified actual or likely pathway, and a potential adverse effect to the receptor from exposure to that emission. Where there is no actual or likely pathway and/or no receptor, the emission will be screened out and will not be considered as a Risk Event. In addition, where an emission has an actual or likely pathway and a receptor which may be adversely impacted, but that emission is regulated through other mechanisms such as Part IV of the EP Act, that emission will not be risk assessed further and will be screened out through Table 13.

The identification of the sources, pathways and receptors to determine Risk Events are set out in Table 13 below.

Table 13: Identification of emissions, pathway and receptors during mining operations

Risk Events						Continue to detailed risk assessment	Reasoning
Sources/Activities		**Potential emissions**	**Potential receptors**	**Potential pathway**	**Potential adverse impacts**		
Pre-mining works	Clearing of native vegetation, topsoil stripping and O/B removal	Oxidation of ASS	Groundwater, groundwater dependent vegetation	Leaching from in situ material	Groundwater contamination (acidification)	No	Disturbance of ASS material during topsoil stripping and O/B removal has not been further risk assessed for the reasons stated above.
		Noise	21 residences, users of the Brand Hwy (see above)	Air / wind dispersion	Amenity impacts	Yes – refer to section 9.4	Potential impacts on amenity to nearby receptors.
		Fugitive emissions (dust)			Amenity and human health impacts	Yes – refer to section 9.5	Potential impacts on amenity to nearby receptors.
Category 8: Mineral sands mining or processing: premises on which mineral sands ore is mined, screened, separated or otherwise processed	Mining and processing of ore	Oxidation of ASS	Groundwater, groundwater dependent vegetation	Leaching from in situ material	Groundwater contamination (acidification)	Yes – refer to section 9.7	Potential impacts on groundwater quality, beneficial users and environmental values.
		Noise	21 residences, users of the Brand Hwy (see above)	Air / wind dispersion	Amenity impacts	Yes – refer to section 9.4	Potential impacts on amenity to nearby receptors.
		Fugitive emissions (dust)			Amenity and human health impacts	Yes – refer to section 9.5	Potential impacts on amenity to nearby receptors.
			Vegetation, including riparian vegetation adjacent to mine voids		Soil contamination, etc. (see above)	No	Dust loading on vegetation from mining and processing of ore has not been further risk assessed due to the temporary nature of the mining operation (5 – 6 years). The Delegated Officer considers that any actual dust impacts can be regulated under the provisions of Section 49 of the EP Act.
		Contaminated stormwater	Surface waters, wetlands, ecosystems adjacent to stockpiles	Direct discharge	Contamination of surface waters, etc. (see above)	Yes – refer to section 9.8	Potential impacts to off-site environmental values; erosion and sedimentation.
	Return water pipelines	Rupture of pipeline causing return water discharge to land or waters	Vegetation, including riparian vegetation adjacent to pipeline alignment	Direct discharge	Soil and surface water contamination, etc. (see above)	Yes – refer to section 9.6	Potential impacts to surface waters, wetland, ecosystems adjacent to the pipeline alignment.
	HMC stockpile	Seepage of water entrained within the HMC to groundwater	Groundwater, groundwater dependent vegetation	Through base of HMC pad	Groundwater contamination	No	Seepage to groundwater from the HMC stockpile has not been further risk assessed due to the low water content of the HMC and low volumes of seepage expected.
					Groundwater mounding	No	
		Contaminated stormwater	Surface waters, wetlands, ecosystems adjacent to stockpiles	Direct discharge	Contamination of surface waters, etc. (see above)	Yes – refer to section 9.8	Potential impacts to off-site environmental values; erosion and sedimentation.
		Dust lift-off	21 residences, users of the Brand Hwy (see above)	Air / wind dispersion	Amenity and human health impacts	Yes – refer to section 9.5	Potential impacts on amenity to nearby receptors.
			Vegetation, including riparian vegetation adjacent to stockpile		Soil contamination, etc. (see above)	No	Dust loading on vegetation from mining and processing of ore has not been further risk assessed for the reasons stated above.
	Disposal of sand tailings (mine void)	Seepage of water entrained within the sand tailings to groundwater	Groundwater, groundwater dependent vegetation	Through base of mine void	Groundwater contamination	No	Sand tailings (consisting principally of silica sand) to be returned to the mine void will have undergone wet separation only and are unlikely to contain contaminants that might otherwise be present in sand tailings that have undergone secondary processing (i.e. mostly clean sand). As the HMC will be shipped overseas (China) for secondary processing, no tailings will be returned for disposal. The Delegated Officer therefore considers the material risk of groundwater contamination from sand tailings to be Low and does not require further risk assessment.
					Groundwater mounding	No	The Delegated Officer notes there has been a significant emphasis on potential impacts from dewatering drawdown on the shallow groundwater resource, other groundwater users and nearby environmental values, and that this aspect been subject to rigorous assessment under Part IV and the RIWI Act. In order to offset drawdown impacts, re-infiltration of tailings water (in addition to aquifer reinjection of dewatering water) has been authorised as a key mitigation strategy - mine voids will therefore be operated to promote infiltration/seepage. The Delegated Officer therefore considers the material risk of groundwater mounding to be Low and does not require further risk assessment.

Risk Events						Continue to detailed risk assessment	Reasoning
Sources/Activities		**Potential emissions**	**Potential receptors**	**Potential pathway**	**Potential adverse impacts**		
		Rupture of pipeline causing mine tailings discharge to land or waters	Vegetation, including riparian vegetation adjacent to pipeline alignment	Direct discharge	Soil and surface water contamination, etc. (see above)	Yes – refer to section 9.6	Potential impacts to surface waters, wetland, ecosystems adjacent to the pipeline alignment.
	Drying of clay slimes (solar drying ponds)	Seepage of water entrained within the clay slimes to groundwater	Groundwater, groundwater dependent vegetation	Through base of pond	Groundwater contamination	No	The Delegated Officer considers the volume of seepage from clay slimes in the solar drying ponds to be low and does not require further risk assessment.
					Groundwater mounding	No	Groundwater mounding caused by seepage from clay slimes has not been further risk assessed for the reasons stated above.
		Rupture of pipeline causing slimes discharge to land or waters	Vegetation, including riparian vegetation adjacent to pipeline alignment	Direct discharge	Soil and surface water contamination, etc. (see above)	Yes – refer to section 9.6	Potential impacts to surface waters, wetland, ecosystems adjacent to the pipeline alignment.
		Dust lift-off	21 residences, users of the Brand Hwy (see above)	Air / wind dispersion	Amenity and human health impacts	No	Fugitive dust from the solar drying ponds causing off-site impacts has not been further risk assessed due to the location of the ponds on the Premises and the distance to sensitive receptors. The Delegated Officer considers that any actual dust impacts can be regulated under the provisions of Section 49 of the EP Act.
			Vegetation, including riparian vegetation adjacent to stockpile		Soil contamination, etc. (see above)	No	Dust loading on vegetation from mining and tailing operations has not been further risk assessed for the reasons stated above.
		Overtopping/breach of containment causing discharge to land or waters	Vegetation, including riparian vegetation adjacent to pond	Direct discharge	Soil and surface water contamination, etc. (see above)	No	Solar drying ponds are to be constructed on-path (within the mine void). Any breaches of pond walls will be contained within the mine void.
	Naturally Occurring Radioactive Materials (NORM)	Seepage to groundwater	Groundwater, groundwater dependent vegetation	Lateral or vertical seepage through base of mine void	Groundwater contamination	No	Radiation management is regulated by DMIRS.
Other	Dewatering	Excess mine water	Groundwater	Direct discharge (aquifer reinjection)	Groundwater mounding	No	Groundwater mounding caused by aquifer re-injection has not been further risk assessed for the reasons stated above.
					Groundwater drawdown	No	Managed under Part IV.
					Groundwater contamination	No	
	Disposal of inert non-mining waste within the mine void	Noise	21 residences, users of the Brand Hwy (see above)	Air / wind dispersion	Amenity impacts	No	The Delegated Officer expects that some additional noise and dust will be generated during waste disposal activities, however does not consider the levels will be significantly different from noise and dust levels during normal operations at the Premises.
		Fugitive emissions (dust)				No	
		Leachates and gaseous emissions	Groundwater, groundwater dependent vegetation	Direct discharge	Groundwater contamination	No	Waste proposed for disposal within the mine void includes inert non-mining wastes, such as wastes from on-site clean ups, maintenance, construction, operation and decommissioning activities, as mining progresses. Regulatory controls will be imposed on the licence to limit the type and amount of waste permitted for disposal, and the conditions under which the waste must be disposed. The Delegated Officer expects that waste disposal on the Premises will be consistent with the State Government's Waste Avoidance and Resource Recovery Strategy 2030, where the only non-mining wastes to be disposed on the Premises are those which cannot reasonably be reused, recycled or disposed off-site to an appropriate licensed landfill facility.

8.2 Consequence and likelihood of risk events

A risk rating will be determined for risk events in accordance with the risk rating matrix set out in Table 14 below.

Table 14: Risk rating matrix

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

DWER will undertake an assessment of the consequence and likelihood of the Risk Event in accordance with Table 15 below.

Table 15: Risk criteria table

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

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

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

"onsite" means within the Prescribed Premises boundary.

8.3 Acceptability and treatment of Risk Event

DWER will determine the acceptability and treatment of Risk Events in accordance with the Risk treatment in Table 16 below:

Table 16: Risk treatment table

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

8.4 Risk Assessment – Impact to off-site receptors from noise emissions

8.4.1 Description of risk event

Noise from operating heavy earthmoving equipment and fixed plant, causing adverse impacts to amenity at nearby residences.

8.4.2 Identification and general characterisation of emission

Noise will be generated from the operation of mobile earthmoving equipment and fixed plant as part of mining and processing activities. Mining, screening and processing of ore will occur continuously (24 hours per day).

A Noise Impact Assessment carried out by Lloyd George Acoustics (LGA 2018) predicted minor exceedances of the Noise Regulations at the two closest receptors during night-time mining and overburden removal on Sundays and during weekday evening hours whilst mining in Pits A, B & C (Stage 1). However, compliance could be achieved if the mining fleet is reduced during these times, in addition to other noise controls (refer to Section 5.2).

An updated Noise Impact Assessment (LGA, 2019) predicted that operating the FPP at natural ground level (behind existing waste dumps and noise bunds) instead of in-pit did not significantly impact on predicted noise levels, providing a restricted mining fleet is used. In addition, noise compliance during mining in the southern portion of the mine site is unlikely to be achievable, and extreme noise controls would be required that would likely render the operation unviable.

8.4.3 Description of potential adverse impact from the emission

Noise can cause nuisance and a reduced quality of life and health for human populations, particularly when the source is located near sensitive receptors. Noise can affect the psychological status of human populations nearby in terms of emotional stress, anger and physical symptoms. Frequency, intensity, duration, meteorological conditions and distance to receptor are all factors which may affect the impact of noise emissions on sensitive receptors.

8.4.4 Criteria for assessment

Noise Regulations

The *Environmental Protection (Noise) Regulations 1997* (Noise Regulations) operate as a prescribed standard under the EP Act.

Assigned levels

The Noise Regulations deal with noise passing from one premise to another, and prescribes assigned levels (the highest levels that can be received) at different types of receivers. A summary of the assigned levels applicable to the Application is set out in Table 17.

Table 17: Assigned noise levels applicable to the Application

Type of premises receiving noise	Time of day	Assigned level		
		$L_{A\ 10}$	$L_{A\ 1}$	$L_{A\ max}$
Noise sensitive premises: highly sensitive area	0700 to 1900 hours Monday to Saturday	45 + influencing factor	55 + influencing factor	65 + influencing factor
	0900 to 1900 hours Sunday and public holidays	40 + influencing factor	50 + influencing factor	65 + influencing factor
	1900 to 2200 hours all days	40 + influencing factor	50 + influencing factor	55 + influencing factor
	2200 hours on any day to 0700 hours Monday to Saturday and 0900 hours Sunday and public holidays	35 + influencing factor	45 + influencing factor	55 + influencing factor
Noise sensitive premises: any area other than highly sensitive area	All hours	60	75	80

The $L_{A\ 10}$ noise level is the most significant for the Premises, as this is representative of the continuous noise emissions expected during mining operations, and is the level which is not to be exceeded for more than 10% of the Representative Assessment Period.

Penalties

In addition to noise levels, penalties may also apply if noise is emitted with annoying characteristics, i.e. noise that is tonal (contains a definite note or pitch, e.g. whining, droning), impulsive (is brief and abrupt, e.g. banging, thumping) or modulated (has a repeated cyclic pattern, e.g. like a siren).

Construction sites

Under Regulation 13, noise from construction work on construction sites need not comply with the assigned noise levels when the work is carried out between 0700 and 1900 hours (excluding Sundays and public holidays), is conducted in accordance with AS 2436, and the equipment used is the quietest reasonably available.

For noise to be exempted under Regulation 13 the site must meet the definition of a *construction site* and the work must meet the definition of *construction work*. DWER considers that although some activities during operation of a mineral sands mine may be considered to

be construction, they do not meet the definition of construction work under Regulation 13, as they are considered to be part of the actual mining activity, i.e. overburden removal and stockpiling of ore for commissioning.

Key finding:

The Delegated Officer notes the Licence Holder has agreed that overburden removal phase is not 'construction work' under Regulation 13, and that compliance with the assigned noise levels is required.

Must take reasonable measures

Section 51(b) of the EP Act requires occupiers of premises to take all reasonable and practicable measures to prevent or control emissions. The onus is therefore on the mine operator to ensure that impacts to amenity are as low as reasonably practicable, even if noise levels comply with the Noise Regulations.

8.4.5 Licence Holder controls

The Licence Holder has prepared a noise management plan to outline its approach to managing noise emissions arising during mine construction works and subsequent operations. A summary of the proposed controls are set out in Table 18 below.

Table 18: Licence Holder's proposed controls for noise emissions

Project area	Mitigation/management action
All areas	The quietest reasonably available equipment, machines and vehicles to be used on site, will be routinely maintained
	Earthmoving equipment to be fitted with muffling exhausts and exhausts redirected
	Broadband reversing beepers to be used on mobile equipment
	Noise bunds ranging in height from 5 – 19 m to be maintained during specific operational scenarios
WCP	WCP located as low as possible into the side of the hill
	WCP sides fitted with cladding
	Pumps enclosed
Mining unit / FPP	FPP to be installed at natural ground level, and operate behind waste dump bunds
Mine pits	Conduct noise monitoring to validate the LGA (2017) noise model
	Conduct quarterly attended noise monitoring at 3 locations during Phases 1 – 3 (Receptors D, E and F), and at 2 different locations during Phases 4 5 (Receptors E and J)

Limits and targets

In addition, the Licence Holder has set internal trigger levels that will trigger noise investigations and additional mitigation. Trigger levels have been set at 85% of the assigned noise levels at receiver monitoring locations, and the assigned levels for 'any other area other than highly sensitive area' will be used as a target at the Premises boundary (Table 19).

Table 19: Licence Holder's proposed trigger levels for noise emissions

Type of premises receiving noise	Time of day	Assigned level		
		$L_{A\ 10}$	$L_{A\ 1}$	$L_{A\ max}$
Receiver	0700 to 1900 hours Monday to	38	47	55

	Saturday			
	0900 to 1900 hours Sunday and public holidays	34	42	55
	1900 to 2200 hours all days	34	42	47
	2200 hours on any day to 0700 hours Monday to Saturday and 0900 hours Sunday and public holidays	30	38	47
Premises boundary	All hours	60	75	80

Contingency actions

In the event a noise-related complaint is received by the Licence Holder or DWER, or quarterly noise monitoring indicates that a trigger level has been exceeded, the Licence Holder will implement the following actions:

- Conduct targeted attended monitoring to verify the complaint;
- If the trigger level has been exceeded, then an investigation will be conducted to verify if the exceedance is attributed to the mine;
- If it is determined the mine is attributing to the exceedance, the remedial action(s) will be taken (see below); and
- Targeted noise monitoring will be conducted to verify if the remedial action(s) have been successful.

Remedial actions

The Licence Holder has proposed a number of remedial actions, in addition to the management actions listed in Table 18. A number of the actions listed may have been implemented prior to each phase. The remedial actions are listed below in Table 20.

Table 20: Licence Holder's proposed remedial actions

Activity	Remedial action(s)
Loading trucks with excavator	Build noise bund around work area
	Relocate excavator to a bench lower in the pit
	Reduce excavator fleet to one operator (night mining)
	Cease operating excavator in adverse wind conditions
Trucking of overburden to temporary stockpile	Maintain noise bund on western side of haul road
	Redirect trucks to haul material to direct return on surface, or in-pit only
	Cease operating haul trucks in adverse wind conditions
Bulldozer at overburden stockpile	Move dump tip head to a lower bench in the pit
	Re-route trucking so tip head is in-pit
	Trucks can paddock dump so no dozer is needed for a shift
	Cease operating dozer in adverse wind conditions
Hauling of ore to ROM	Maintain noise bund along western side of haul road
	Reduce fleet of scrapers hauling ore
	Haul ore on day shift only
Loader/excavator at the ROM	Maintain noise bunds around the ROM and SMU
	If excavator is sitting high to feed the SMU reduce the height of the pad
	Slow feed rate
	Stop feeding
Hauling of product	Build noise bund on western side of main access road

Activity	Remedial action(s)
	Reduce fleet hauling HMC
	Haul ore on day shift only
Wet Concentrator Plant	Maintain cladding on the WCP
	Maintain noise bund around the WCP
Full production – Overburden removal	Reduce haul truck fleet during Sunday daytime (9:00 AM – 10:00 PM) and evenings (7:00 PM – 10:00 PM)
Full production – Mining operations (night time)	Pit C, Stage 1 – reduce haul truck fleet to max. 8 (mix of CAT 785 and CAT 777) with 4 in the pit and up to 4 at/near the surface for overburden removal
	Pit B – reduce haul truck fleet to max. 7, with all trucks assumed in the pit area for overburden removal
	Pit A – reduce haul truck fleet to max. 7, with all trucks assumed in the pit area and travelling close to the pit face at all times to maximise noise barrier effects to receptor A
	All pits – only use Excavators PC3600, one in the pit and the other near surface

8.4.6 Key findings

The Delegated Officer has reviewed the information regarding the risk of mine noise impacting on sensitive receptors and has found:

1. Compliance with the Noise Regulations is reliant on the implementation of noise controls during specific mining scenarios. These include:
   - Reducing mine fleet during night-time mining;
   - Constructing sizeable noise bunds during specific mining phases;
   - Utilising only one excavator during night-time operations, and working behind the bunds;
   - Continuous, real-time monitoring of noise emissions.
2. The controls proposed by the Licence Holder require expanding to mitigate the risk of noise non-compliance, including continuous, real-time noise monitoring.
3. The local area is a quiet, rural area – therefore any increase in noise levels may be considered significant to nearby receptors. In addition to the management strategies proposed by the Licence Holder, some of the remedial actions proposed in the Noise Management Plan are required to be implemented at the start of the Project, in order to ensure impacts to amenity are as low as reasonably practicable.
4. The Licence Holder has agreed that overburden removal is not ‘construction work’ under Regulation 13, and that compliance with the assigned noise levels is required.

8.4.7 Consequence

The Noise Regulations prescribe the allowable levels of noise that can be received at a receptor. Noise received above the allowable levels is considered unacceptable; however noise may also be considered unacceptable if emitted in a manner that is not as low as reasonable practicable, even if the received levels are below the allowable level.

The consequence of noise emissions exceeding the allowable levels at nearby receptors, or emitted in a manner that is not as low as reasonable practicable, may result in impacts to amenity, causing concern and complaints – particularly if it disturbs sleep at night. The level of impact to amenity can be influenced by many factors, including the amplitude of the exceedance (e.g. 1 dB is barely noticeable, compared to 10 dB which is usually twice as loud), the length of the exceedance, the time of day of the exceedance (night vs. day), or if it contains annoying characteristics (i.e. tonality, impulsiveness or modulation).

The Delegated Officer therefore considers the consequence of noise emissions from operations causing impacts to the amenity of nearby receptors to be **Moderate**.

8.4.8 Likelihood of Risk Event

The Delegated Officer notes that mineral sands mines are complex sites involving many different activities that produce different types of noise, that vary depending on the time of day and type and location of the mining activities. In addition the mining of mineral sands, in general, is a progressive process whereby new pits are opened and as the mine progresses old pits are backfilled. Given the temporary nature of the mining process, the impact of noise on any one particular receptor is unlikely to be constant and/or consistent throughout the life of mine, as the mine path progresses.

In DWER's experience of previous and existing mineral sands mines, noise emissions can become a significant issue for sensitive receptors in close proximity to mines that have continuous (24 hours per day) operations. This is particularly common for mines located in quiet, rural areas where background noise levels are very low, i.e. < 20 dB(A), and therefore any increase in noise levels is likely to be considered significant to nearby receptors.

In considering the noise modelling for the Project, the Delegated Officer considers it **Possible** that noise emissions from mining operations will cause impacts to the amenity of nearby receptors (at one point in time or another, most likely under worst case operating conditions during specific mining scenarios).

8.4.9 Overall rating of noise emissions

The Delegated Officer has compared the consequence and likelihood ratings described above with the risk rating matrix (Table 14) and determined that the overall rating for the risk of noise emissions causing impacts to the amenity of nearby receptors is **Moderate**.

8.5 Risk Assessment – Impact to off-site receptors from fugitive emissions (dust)

8.5.1 Description of risk event

Dust generated from mining operations and exposed areas/stockpiles, causing adverse impacts on the health and/or amenity of local receptors and users of the Brand Hwy.

8.5.2 Identification and general characterisation of emission

Dust, or total suspended particulate matter (TSP), is comprised of coarse particulate matter (CPM), which is generally comprised of particles greater than 10 micron (µm) in diameter, and the respirable fraction comprised of particles less than 10 µm in diameter (PM_{10}). The majority of dust generated during the operation of a mineral sands mine is CPM, being comprised of unprocessed mineral oxide particles.

Sources of dust may include fugitive dust from exposed mining areas, open areas or rehabilitated surfaces, overburden/ topsoil/ product/ waste stockpiles, movement of vehicles along haul roads and access tracks, and the mining, screening, processing and transporting of ore.

8.5.3 Description of potential adverse impact from the emission

Dust emissions can be harmful to human health and the environment. Human health effects of dust tend to be associated with PM_{10} and $PM_{2.5}$, which tend to remain suspended in the air for longer periods and can penetrate into the lungs. Elevated TSP levels may cause nuisance impacts, however the finer particle fraction (< PM_{10}) may pose a health risk as indicated above.

The Mid west region experiences a mild Mediterranean climate with hot/dry summers and mild/wet winters. The climate is strongly influenced by seasonal wind patterns, with the local area known for its strong off and on-shore winds (summer sea breezes frequently reach 46

km/hr or more).

DWER has identified 24 farm houses within a 5 km radius of the Premises boundary, with the majority located west of the mine and downgradient from the steep Dandaragan Plateau. In addition the Brand Hwy, being a primary road and major transport route, runs immediately adjacent to the western boundary of the Premises (the Brand Hwy is considered to be a sensitive land use). DWER has identified the 4 closest farm houses as being at risk of being impacted from nuisance dust during strong prevailing easterly winds, and 2 farm houses at risk when the winds are from the south/south-west.

In DWER's experience of previous and existing mineral sands mines, fugitive dust during adverse weather conditions can cause concern or complaints from residents within proximity to the mine, particularly those who suffer from asthma or hayfever. Other common complaints include impacts on amenity (hanging out washing, entertaining outdoors, etc.), and the response time of the mine to resolve excessive dust when the receptor is being/has already been impacted.

8.5.4 Criteria for assessment

Separation distance

DWER considers a minimum separation distance of 1,000 – 2,000 m is required between mineral sands mining operations and sensitive land uses, to minimise the risk of impacts from light overspill, dust and noise.

Air quality standards

There are no directly applicable ambient air quality standards for the Premises.

The Ambient Air Quality NEPM provides a benchmark against which the risk of adverse health effects arising from exposure to PM_{10} (from any source) can be assessed (but is not considered a regulatory standard), and is shown in Table 21.

Table 21: Ambient Air Quality NEPM – Standards for pollutants

Pollutant	Averaging period	Maximum concentration standard	Maximum allowable exceedances
Particulates as PM_{10}	24 hours	50 µg/m^3	None
	Annual	25 µg/m^3	

The Kwinana EPP also provides an equivalent ambient air quality standard and limit with respect to TSP emissions from industry. Given the siting context and distances to residential and sensitive receptors, the standard and limit set for Policy Area C (rural and residential land, i.e. non-industrial) is considered to be the most relevant and is shown in Table 22.

Table 22: Kwinana EPP ambient air quality standards and limits for TSP

Policy Area	Averaging period	TSP standard	TSP limit
Area C	24 hours	90 µg/m^3	150 µg/m^3

8.5.5 Licence Holder controls

The Licence Holder has prepared an Air Quality Management Plan to outline its approach to managing fugitive dust emissions arising during mine construction works and subsequent operations. A summary of the proposed controls are set out in

Table 23 below.

Table 23: Licence Holder's proposed controls for dust emissions

Activity	Mitigation/management action
Management	Overburden and waste material will be returned directly to the mine void, to minimise double-handling and excessive stockpiling
	Water sprays will be applied to any material that poses a dust risk
	Implementation of vehicle speed limits
	Unsealed roads will be sprayed with water on a regular basis using a dedicated water truck
	Dust emissions from stockpiles will be minimised by using water cannons from mobile water trucks when required
	Areas will not be disturbed unless required
	Temporary crops may be grown to bind soil
	Dust suppression sprinklers at the processing plant will focus on transfer points
	Biodegradable stabilising agents may be used
	Progressive rehabilitation will occur straight after mining has been completed in an area
	Continuous TSP and PM_{10} monitoring equipment will be fitted with trigger alarms to notify mine management when the NEPM standard levels have been exceeded for over 10 minutes
Monitoring	A TSP, PM_{10} and dust settlement monitoring program will be implemented, consisting of continuous monitoring at the four closest receptors
	Opportunistic inspections of dust levels will be undertaken during construction and operation
	If visible dust emissions are noted then an assessment of the source will be made and additional water will be applied to key source areas, or alternative treatments applied
	The potential for windy conditions will be monitored and extra water applied in preparation

8.5.6 Key findings

The Delegated Officer has reviewed the information regarding the risk of fugitive dust impacting on sensitive receptors and has found:

1. The local area is strongly influenced by seasonal wind patterns, and is known for strong off- and on-shore winds.
2. There are a number of sensitive receptors within proximity to the Premises, located to the west and down gradient of the Dandaragan Plateau, that are considered at risk of being impacted by fugitive dust.
3. Dust controls proposed by the Licence Holder lack specific detail and are inadequate/ incommensurate with the risk.
4. A high level of regulatory control is required to ensure fugitive dust does not impact off-site receptors.

8.5.7 Consequence

The consequence of TSP impacting on sensitive receptors located off-site or on the Brand Hwy

is likely to be of nuisance value, causing amenity impacts by settling on surfaces and causing soiling and/or discolouration (**Moderate**).

The consequence of PM_{10} impacting on sensitive receptors is likely to constitute exposure to a hazard with short-term adverse health effects (requiring treatment) and impact to amenity for short periods (**Moderate**).

8.5.8 Likelihood of Risk Event

Given the proximity of sensitive receptors and their location in the landscape, in addition to the prevailing local weather conditions during the summer months, and the inadequate level of dust controls proposed by the Licence Holder, the Delegated Officer considers it **Likely** that TSP and PM_{10} generated from the Premises will impact on sensitive receptors (at one point in time or another, most likely under worst case operating conditions during specific mining scenarios).

8.5.9 Overall rating of fugitive emissions (dust)

The Delegated Officer has compared the consequence and likelihood ratings described above with the risk rating matrix (Table 14) and determined that the overall risk rating for fugitive emissions (dust) causing impacts to the health and/or amenity of nearby receptors is **High**.

8.6 Risk Assessment – Slurry pipeline failure

8.6.1 Description of risk event

Failure of slurry pipelines, releasing HMC and/or mine tailings (sand tailings, silts and clay slimes,) into the environment and causing adverse impacts on surface waters, wetlands, native vegetation or soil over a localised area.

8.6.2 Identification and general characterisation of emission

Sand tailings, silts and clay slimes comprise the coarse-grained (typically quartz sand) and fine-grained (typically silt sized clay material) solid material remaining after the heavy mineral concentrate has been separated from the mined ore, and are slurried with process water to facilitate transfer.

The clay slimes material is characterised as having very high clay content (approx. 77%) with no coarse fraction and a very high modulus of rupture, indicating a very high potential to hardset. The slimes are classed as having neutral pH (pH 6.9 $CaCl_2$) and being ‘very saline’ (EC 1.19 dS/m) (Outback Ecology, 2013). Clay minerals have a great affinity for water, with the ability to soak up ions from a solution and release them when conditions change, which can result in the transportation/dispersion of contaminants from one area to another (USGS, 1999).

8.6.3 Description of potential adverse impact from the emission

A number of important wetlands and groundwater dependent vegetation occur down hydraulic gradient of the Premises, west of the Brand Hwy (e.g. White Lake, Beermullah Lake, Collards Wetland, etc.). If spills or leaks of mine tailings reach these systems, it may cause contamination through sedimentation (increased concentration of suspended sediments (i.e. turbidity) and an increased accumulation of fine sediments) and potentially a number of other adverse effects on ecosystem health.

8.6.4 Licence Holder controls

Pipelines from the WCP to the FPP or solar drying ponds will run parallel with the mining haul road in pipeline corridors that sit slightly below natural ground surface.

Pumps and slurry flow will be monitored with flow meters at designated pumping stations. The operator in the control room will monitor flow readings, and pressure gauges throughout the pipeline system will alert the operator of issues.

The Licence Holder considers that any spills or leaks from pipelines will be localised and contained on the Premises.

8.6.5 Key findings

The Delegated Officer has reviewed the information regarding the risk of pipeline failure/overtopping of mine tailings infrastructure and has found:

1. There is a possibility that important wetlands and groundwater dependent vegetation may be impacted from a spill or leak of mine tailings.
2. The risk of impacts is mitigated for low velocity leaks by running pipelines adjacent to the mining haul road and below the natural ground surface.
3. Flow meters and pressure gauges on the pipelines should enable early detection of spills and/or leaks.

8.6.6 Consequence

The consequence of spills or leaks of clay slimes and/or sand tailings from pipeline failure would constitute a potential or actual alteration of the environment, with the potential for off-site impacts at a local scale (**Minor**).

8.6.7 Likelihood of Risk Event

The Delegated Officer considers that any spills or leaks of clay slimes or sand tailings will be localised and contained on the Premises, and is **Unlikely** to cause off-site impacts to environmental values.

8.6.8 Overall rating of fugitive emissions (dust)

The Delegated Officer has compared the consequence and likelihood ratings described above with the risk rating matrix (Table 14) and determined that the overall rating for a pipeline failure causing impacts to environmental values is **Moderate**.

8.7 Risk Assessment – Sulfide oxidation (Acid Sulfate Soils)

8.7.1 Description of risk event

Direct disturbance (i.e. physical movement) or indirect disturbance (e.g. lowering of the water table) of ASS, causing acidification of groundwater and degradation of water quality and other environmental values.

8.7.2 Identification and general characterisation of emission

ASS occur naturally in soils and sediments that contain iron sulfide minerals (principally as the mineral pyrite) and/or their precursors. These minerals are typically found at shallow depth (less than 3 m deep) in low-lying areas near the coast and are harmless when left in a waterlogged, undisturbed environment, but have the potential to cause environmental problems due to the generation and release of sulfuric acid when exposed to air through drainage, dewatering or excavation (DER, 2015c).

Sulfidic sediments may also occur at depths greater than 3 metres on the coastal plains, which can be disturbed by large-scale sand mining operations. Although the general principles for managing these deeper sulfidic sediments are similar to that of managing shallow acid sulfate soils, the scale of mining operations and the characteristics of these deeper sediments can cause additional hazards on disturbance that require careful management to prevent environmental problems taking place.

An ASS investigation (SWC, 2017) identified soils indicative of potential ASS (PASS) material at the boundary between the base of the Yoganup Formation and upper portion of the Leederville Formation, which correlates to the base (or just below) of the proposed mining pits (refer to

Section 0). Modelling indicates approximately 19.8 tonnes of ASS material is expected to be directly disturbed by mining, which constitutes ~0.1% of the total material proposed to be mined.

8.7.3 Description of potential adverse impact from the emission

ASS pose a number of significant environmental risks such as:

- Deoxygenation – the oxidation process consumes oxygen, and in extreme cases can remove all of the oxygen from the water column, resulting in the death of aquatic organisms;
- Release of metals and metalloids – many heavy metals (such as cadmium and lead) and metalloids (such as arsenic) form sulfidic minerals, which if oxidised, are released into the pore water or into the overlying water column, where they may be incorporated into animal or plant tissue and potentially into the food chain; and
- Impacts on public health – loss of amenity (preventing aquatic ecosystems being used for recreation), the generation of four odours (including toxic hydrogen sulfide), and impaired drinking water.

8.7.4 Criteria for assessment

The DWER guideline *Identification and investigation of acid sulfate soils and acidic landscapes* (DER, 2015c) is the accepted framework in Western Australia for assessing and managing environmental risks associated with ASS.

The framework underpins the management of ASS and water resources to avoid unacceptable impacts and involves:

- developing a sound conceptual model for the site, including an understanding of local hydrogeological conditions, of the distribution of sulfide minerals, and of the presence of sensitive environmental receptors;
- identifying risk mitigation measures on the basis of the conceptual model, and making firm commitments that these measures will be implemented; and
- developing a long-term contingency plan, incorporating a commitment to undertake appropriate monitoring accepted by regulatory agencies.

The assessment is undertaken in an iterative manner where the suitability of site-specific data for making reliable management decisions is repeatedly questioned until a consensus is reached between the Licence Holder, DWER and other regulatory agencies (i.e. DMIRS).

8.7.5 Licence Holder controls

The Licence Holder has developed a conceptual model for the site, including a description of local hydrogeological conditions and the spatial distribution of sulfide minerals (SWC, 2017). Management and contingency strategies outlined in the DWER guideline *Treatment and management of soils and water in acid sulfate soil landscapes* (DER, 2015d) have been considered on the basis of the conceptual model. A summary is provided in Table 24 below.

Table 24: Licence Holder's proposed controls for managing ASS

Type	Site applicability
Avoidance	Based on the pre-screening geological data, no areas within the proposed orebody have been excised
Minimise disturbance	Disturbance of PASS material will be staged, minimising exposure time of reactive material
Neutralisation	If required, soil and/or water will be neutralised using lime at the rate determined by the following equation: Lime requirement (kg $CaCO_3$/t) = Net Acidity (mol H^+/t) x 0.05 Based on the amount of PASS material expected to be exposed, the total potential acidity that could be released by direct disturbance is 1,817,460

	mol H^+; therefore approx. 100 tonnes of lime is estimated for effective neutralisation
Strategic reburial	This will be considered for oversize material within the mine pits and is likely to be undertaken in conjunction with soil neutralisation methods (see above)
Hydraulic separation	Not applicable as the proportion of PASS material within the ore is negligible (<2%)
Stockpiling	This will be considered in conjunction with soil neutralisation methods (see above)
Monitoring – routine screening	In-pit soil screening: - regular in-pit screening of material, based on mine scheduling; - frequency to be determined by the Licence Holder's environmental department
	Tailings sand testing: - will depend on the proposed utilisation of the material: - if to be used as a growth medium for rehabilitation, screen testing at a rate of 1 sample per 1,000 m^3 - if to be used to reconstruct the lower portion of the backfill profile then no monitoring will be conducted
	Fines material testing: - clay slimes will be screened prior to backfilling solar drying ponds; - 2 sampling sites per hectare, with samples collected at 0.5 m vertical intervals - detailed analysis to be conducted on a selected number of samples to confirm screen test results and the absence of PASS
	Process water neutralisation: - routine water monitoring to confirm characteristics - monthly monitoring is surrounding bores, water dams, HMC sumps and solar drying ponds - routing pH monitoring within the WCP - if pH drop below pH 4, then field testing will occur weekly in all process water/waste deposition areas
	Groundwater quality[1]: - monthly testing of all bores on the Premises for pH, EC and TDS - quarterly testing of major ions and metals/metalloids
	Post treatment verification: - take representative in-pit sampling within reactive areas which have required treatment after disturbance, to test effectiveness of soil neutralisation - groundwater monitoring as indicated above

Note 1: Mine pit dewatering will be managed in accordance with the Groundwater Operating Strategy. The groundwater monitoring program will be undertaken to detect changes in groundwater quality that could be attributed to dewatering and off-site impacts. Monitoring will provide an early indication of adverse effects of ASS on local groundwater, both during operations and mine closure.

8.7.6 Key findings

The Delegated Officer has reviewed the information regarding the risk of sulfide oxidation and has found:

1. The low number of samples that tested positive for pyrite minerals suggests that ASS is

manageable at the site.

2. Management and contingency measures proposed by the Licence Holder for managing the risk of sulfide oxidation in sediments that contain significant amounts of sulfide minerals appear suitable; however the risk of groundwater contamination by metals due to drawdown has not been addressed.
3. Trigger values for acidity should be developed based on the upper threshold limit value of background levels in groundwater in the area (likely to be ~100 mg/L $CaCO_3$). Where acidity levels are triggered, additional sampling should be undertaken, including full chemical analysis.

8.7.7 Consequence

If not detected or managed early, the consequence of direct and/or indirect disturbance of ASS can lead to long-term environmental impacts at a local level (**Moderate**).

8.7.8 Likelihood of Risk Event

The likelihood ASS disturbance causing long-term environmental impacts at the site is low (**Unlikely**), if a regular screening and groundwater monitoring program is in place.

8.7.9 Overall rating of sulfide oxidation

The Delegated Officer has compared the consequence and likelihood ratings described above with the risk rating matrix (Table 14) and determined that the overall rating for sulfide oxidation is **Moderate**.

8.8 Risk Assessment – Impacts from surface water runoff

8.8.1 Description of risk event

Discharge of surface water runoff, causing erosion and adverse impacts to watercourses and wetlands.

8.8.2 Identification and general characterisation of emission

Contaminants conveyed in stormwater discharges from active haul roads, access roads, heavy vehicle operating areas (e.g. ROM pad), hardstand areas (e.g. plant site), will vary. The activities, contaminant sources, and contaminants detailed in Table 25 are commonly found at mineral sands mine and related facilities.

Table 25: Stormwater contaminant sources and contaminants at mineral sands mines

Activity	Contaminant source	Contaminants
Heavy earthmoving equipment movements – active haul roads, access roads	Surface grading and exposure of soils	Dust, total suspended solids (TSS), total dissolved solids (TDS), turbidity, pH and oil and grease
Mining and processing activities	HMC storage	Dust, TSS, TDS, turbidity, sulfates, iron
	Overburden/topsoil storage	
	Mine voids	
	Materials handling and loading/unloading	
Equipment/vehicle maintenance	Fuelling activities	Diesel fuel, petrol, oil, chemical oxygen demand (COD)
	Parts cleaning	Solvents, oil, heavy metals, acid/alkaline wastes
	Disposal of oily rags, oil filters,	Oil, heavy metals, solvents, acids,

	batteries, coolants, degreasers	COD
Rehabilitation	Site preparation for rehab	Dust, TSS, TDS, turbidity, pH

8.8.3 Description of potential adverse impact from the emission

Rainfall runoff modelling (URS, 2013a) indicates that a 20-year ARI rainfall event is required to exceed infiltration and generate runoff, with peak flow rates ranging from 0.5 to 2 m^3/s. Runoff volumes are predicted to be low (~3% of rainfall for a 100-year ARI event) and represent a low flood risk.

There is an increased potential for erosion in disturbed areas and exposed soils, which may manifest in increased sediment concentrations and loadings in the local surface water flows.

8.8.4 Licence Holder controls

The Premises intersects several drainage lines shedding from the Dandaragan Plateau that will be temporarily diverted and managed to avoid the ingress of associated runoff into mine voids during mining and backfill operations.

The mine operations and processing area will be located outside of the drainage line boundaries. External sheet runoff will be diverted at the upstream side of the infrastructure, with relatively minor bund/channel diversions. Minor bunding will be installed to divert external sheet runoff around laydown/storage areas.

8.8.5 Key findings

The Delegated Officer has reviewed the information regarding the risk of surface water runoff and has found:

1. Streamflow infiltrates the Bassendean Sands on the footslopes of the Gingin Scarp and does not contribute to the wetlands and lakes of the Beermullah Plain.
2. The Surface Water Assessment (URS, 2013c) recommends an appropriate stormwater drainage plan is required for operational areas and upstream sub-catchments. Such a plan was not submitted with the Application.
3. Licence Holder controls for managing surface water runoff do not address the risk of runoff contaminated by activities on the Premises.

8.8.6 Consequence

The consequence of contaminated surface water runoff entering local drainage lines could lead to long-term environmental impacts at a local level (**Moderate**).

8.8.7 Likelihood of Risk Event

The likelihood contaminated surface water runoff causing long-term environmental impacts at the site is low (**Unlikely**), if an appropriate stormwater drainage plan is implemented.

8.8.8 Overall rating of sulfide oxidation

The Delegated Officer has compared the consequence and likelihood ratings described above with the risk rating matrix (Table 14) and determined that the overall rating of impacts from surface water runoff is **Moderate**.

8.9 Summary of acceptability and treatment of Risk Events

A summary of the risk assessment and the acceptability or unacceptability of the risk events set out above, with the appropriate treatment and control, are set out in Table 26 below. Controls are described further in section 1.

Table 26: Risk assessment summary

	Description of Risk Event			Licence Holder controls	Risk rating	Acceptability with controls (conditions on instrument)	Resulting regulatory controls
	Emission	**Source**	**Pathway/ Receptor (Impact)**				
1.	Noise	Heavy earthmoving equipment and fixed plant	Causing amenity impacts to off-site receptors	Equipment and operational controls Routine noise monitoring Setting noise trigger levels and contingency actions Remedial actions	Moderate consequence Possible likelihood **Moderate Risk**	Acceptable subject to proponent controls conditioned and additional regulatory controls	Licence to specify: - Must operate a reduced mining fleet during night time mining - Must use quietest equipment reasonably available - Must install broadband reversing beepers - Must maintain a series of noise bunds on the western flank of Pit C - Must located the mining unit in the mining pit (below natural ground level) - Continuous noise monitoring - Must undertake remedial actions is monitoring indicates exceedance of Noise Regulations - Shut down operations if remedial actions fail to reduce noise
2.	Fugitive dust	Exposed mining areas, stockpiles, vehicle movements, mining and processing activities	Causing health and/or amenity impacts to off-site receptors	Operational controls Routine dust monitoring Visible dust inspections	Moderate consequence Possible likelihood **Moderate risk**	Acceptable subject to proponent controls conditioned and additional regulatory controls	Licence to specify: - Timing of dust generating activities - Must use dust suppression, both water and other than water - Dust monitoring during summer works - Met set trigger values - Reportable events and must conduct an investigation into exceedances

	Description of Risk Event			Licence Holder controls	Risk rating	Acceptability with controls (conditions on instrument)	Resulting regulatory controls
	Emission	**Source**	**Pathway/ Receptor (Impact)**				
3.	Slurry pipeline failure	Direct discharge of clay slimes/ sand tailings	Sedimentation and other effects on health of surface water ecosystems	Routing of pipeline along haul roads Bunding (300 mm) Pressure/flow sensors Daily inspections	Minor consequence Unlikely likelihood **Moderate Risk**	Acceptable subject to proponent controls conditioned and additional regulatory controls	Licence to specify: - Automatic cut-outs/secondary containment/pressure sensors to be maintained on pipelines - Inspections of infrastructure
4.	Acid Sulfate Soils	In situ soils with sulfide minerals	Groundwater contamination (acidification)	Avoidance Minimise disturbance Neutralisation Strategic reburial Stockpiling Routine screening Groundwater monitoring	Moderate consequence Unlikely likelihood **Moderate Risk**	Acceptable subject to proponent controls conditioned	Licence to specify: - Screening during mine path drilling - Must monitor and manage dewatering effluent - Dewatering effluent trigger values – to trigger management actions - Field surveys of overburden - Treatment of PASS in overburden and ore - Groundwater monitoring of ASS parameters - Setting of ASS triggers based on UTC
5.	Contaminated stormwater	Mine site runoff	Erosion, sedimentation and other effects on health of surface water ecosystems	Temporary diversion of drainage lines Bunding installed to divert sheet runoff around laydown/storage areas	Moderate consequence Unlikely likelihood **Moderate Risk**	Acceptable subject to proponent controls conditioned	Licence to specify: - Design of hardstand areas, ROM pads, etc. to divert stormwater runoff to a constructed drainage depression or sedimentation basin

9. Regulatory controls

A summary of regulatory controls determined to be appropriate for the Risk Event is set out in Table 26. The risks are set out in the assessment in section 8 and the controls are detailed in this section. DWER will determine controls having regard to the adequacy of controls proposed by the Licence Holder. The conditions of the Licence will be set to give effect to the determined regulatory controls.

9.1 Licence controls

9.1.1 Authorised emissions

A requirement has been imposed (Condition 2) to specify the authorised location(s) for disposal of mine tailings (waste sand and clay), fugitive dust emissions, noise emissions and indirect emissions to groundwater (i.e. seepage).

Note: *The requirements specified in Table 2 of the Licence generally replicate the details provided in the Mining Proposal for the Premises.*

Grounds: *DWER's risk assessment is based on the disposal of mine tailings in the locations specified in the approved Mine Closure Plan (Preston Consulting, 2018b). Disposal of these materials in locations other than those specified has not been risk assessed, and the defence provisions of s. 74, 74A and 74B would therefore not apply.*

9.1.2 Construction works

The following infrastructure is authorised for construction during mining operations as per the design criteria and specifications outlined in the Application.

Infrastructure	***Requirements (design and construction)***
Solar drying ponds	• *Constructed within previous mine voids or on-mine-path* • *Pond floors must be sloped such that supernatant water can be collected* • *Embankment walls must be constructed with compacted overburden or clayey sand with angle of repose for the outer pond wall being minimum 1:2 (V:H)* • *Height of embankment walls must not exceed 5.0 metres*
Pipelines carrying clay slimes, sand tailings and return water	*Constructed with:* • *Automatic cut-outs in the event of a pipe failure; OR* • *Secondary containment sufficient to contain any spill for a period equal to the time between routine inspections; OR* • *Telemetry systems and pressure sensors along pipelines to allow detection of leaks and failures*
FPP & ROM pads	• *Constructed with compacted overburden material or similar* • *Drainage designed to divert stormwater runoff to a constructed drainage depression or sedimentation basin*
Groundwater monitoring bores	• *Minimum of 2 bores to be constructed immediately down-gradient of each mine pit, at least 6 months prior to commencing mining in that pit;* • *Sited in accordance with WQPN #30 ("Siting of monitoring bores" section);* • *Installed to meet the requirements of Minimum Construction Requirements for Water Bores in Australia;* • *Surveyed to allow the ground level (to AHD) at each location to be accurately determined; and* • *Be screened to permit effective monitoring of shallow groundwater quality in the vicinity of each mine pit.*

Note: *The requirements specified in Table 3 of the Licence generally replicate the design and specifications outlined in the Application and have been determined as being required to mitigate potential risks identified in this Decision Report.*

Grounds: *DWER acknowledges the continuous nature of mineral sands mining and the need to incrementally construct/deconstruct temporary containment infrastructure, such as water management ponds and solar drying ponds, as the mine path advances. In order to avoid triggering s. 53 of the EP Act whenever a new pond is required, the Licence provides an ongoing authorisation for construction, providing the construction is in accordance with specified design criteria, with compliance certification of as-constructed ponds to be provided within the next relevant annual environmental report.*

9.1.3 Infrastructure and equipment

The following environmental controls, infrastructure and equipment should be maintained and operated to manage the risk of impacts to environmental receptors (Conditions 4 & 5):

- Design capacity of all mining and processing infrastructure to be specified;
- HMC stockpile pad to be impervious, and designed to drain surface water runoff to a lined collection sump with sufficient holding capacity;
- Operational freeboard of 0.5 m vertical distance on solar drying ponds to be maintained at all times (whilst operating);
- Daily inspections of freeboard capacity and pipelines for visual integrity and leak assessment to be conducted, to enable early detection and proactive management; and
- Installation of industry standard safeguards for all pipelines carrying tailings and HMC, such as the use of automatic cut-outs, secondary containment, or telemetry and pressure sensors to allow detection of leaks and failures.

Note: *The requirements specified above generally replicate Licence Holder's proposed controls, and were considered in determining the risk of impacts to environmental receptors from operation of specified infrastructure and equipment.*

Additional controls have been determined as being required to mitigate potential risks identified in this Decision Report.

Grounds: *All major mining infrastructure and their current design capacities have been specified in the Licence to reflect the current maximum production capacity of the Premises (as provided by the Licence Holder). Any proposed alterations that would increase the design capacity of this infrastructure will require reassessment in accordance with s. 53 of the EP Act.*

Operational freeboard requirements on solar drying ponds, the use of safeguards for pipelines containing materials that could otherwise pose a risk to the environment, and conducting daily inspections of pipelines and containment infrastructure have been considered necessary to minimise the risk of accidental releases, spills or leaks of mine tailings.

There was insufficient information available to determine the adequacy of controls around surface water runoff from the HMC stockpile. Given the potential quality of water contained within the HMC that will be allowed to drain from the stockpile (i.e. low pH, high salinity), DWER considers that controls are warranted in order to minimise the potential risk of discharge of this water (including infiltration to shallow soils and groundwater), and has therefore specified the minimum design specifications for the pad and collection sump commensurate to this risk.

August 2019 amendment: *the Licence Holder requested the requirement to install a decant system on solar drying ponds to be removed, as there has been no water that has required to be decanted from operations to date due to the WCP achieving much higher densities of clay slimes than expected and high evaporation rates during the hot conditions. The Delegated Officer notes the mine has not yet experienced a winter season, and considers a decant system to be a critical design component that lowers the risk of uncontrolled discharges, such as overtopping and from embankment failure. The Delegated Officer has therefore determined*

to retain the requirement to install a decant system on solar drying ponds, subject to the total freeboard exceeding 250 mm of the maximum 500 mm (i.e. a decant system is not required if the total freeboard remains below 250 mm).

9.1.4 Disposal of mine tailings

A control has been imposed (Condition 6) to specify the nominated location(s) as the authorised disposal area(s) for mine tailings.

Note: *The requirements specified in Table 6 of the Licence is generally consistent with the Mine Closure Plan for the Premises, and includes the use of clay fines for dust suppression purposes.*

Grounds: *DWER's risk assessment is based on the disposal of mine tailings in the locations specified in the approved Mine Closure Plan (Preston Consulting, 2018b). Disposal of mine tailings in locations other than those specified has not been risk assessed, and the defence provisions of s.74, 74A and 74B would therefore not apply.*

August 2019 amendment: *the Licence Holder requested the provision for disposal of clay slimes within mined voids, to facilitate the co-disposal of clay slimes with sand tailings, as the original licence only permits clay slimes to be disposed to solar drying ponds or used for dust suppression. As co-disposal of tailings is an industry standard practice, the Delegated Officer considers this would not result in a change in the material risk of the tailings disposal activity, and therefore has included Pits A, B, C and D as disposal options for clay slimes from the thickener.*

9.1.5 Fugitive dust controls

A number of fugitive dust controls have been specified in Condition 7 (Table 7) of the Licence, including:

- Controls during topsoil stripping;
- Use of water carts and sprays;
- Use of dust suppressants (other than water);
- Conditions under which activities must cease; and
- Monitoring and setting trigger levels.

Note: *The requirements specified in Table 7 generally replicate the management measures proposed by the Licence Holder in the Application, however more detail has been added.*

Grounds: *In the absence of ambient air quality modelling, a higher level of regulatory control is required through the Licence to mitigate the risk of fugitive dust impacting on off-site receptors during mining operations.*

The dust controls specified in Table 7 are consistent with the operation of similar mineral sands mines on the Swan Coastal Plain, and are not considered to be overly onerous. The key control relates to the suspension of specific operations during high wind conditions, where there is a risk of causing off-site impacts. The onus is therefore on the Licence Holder to use available tools (e.g. monitoring) and experience to mitigate the risk.

Continuous dust monitoring during the drier months (Oct – May) is consistent with that proposed by the Licence Holder and is considered necessary to provide assurance over the effectiveness of the dust controls specified in Table 7.

9.1.6 Noise controls

A number of noise controls have been specified in the Licence (Conditions 8 & 9), including:

- Operating a reduced mining fleet during night time operations;
- Maintaining a series of 4 noise bunds on the western flank of Pit C and the process plant area, that vary in height from 13 – 20 m;
- Continuous monitoring of noise emissions, that will supply continuous real-time data to allow real-time monitoring of noise emissions; and

- Operational controls on heavy earthmoving equipment, including:
    - Silencers on mufflers and broadband reversing alarms;
    - Restricting the sound power level of haul trucks; and
    - Cease activities when compliance with the Noise Regulations cannot be achieved (unless an amenity agreement is in place with the affected receptor).

Note: *The requirements specified above generally replicate the controls proposed by the Licence Holder in the updated noise model, which takes into account the significant changes since the original noise assessment, such as the three closest receptors no longer being noise sensitive. Based on this, the controls in the Licence are significantly less onerous than originally proposed during the works approval assessment.*

Grounds: *A review of the updated noise model (2018) for the project indicates that compliance with the Noise Regulations is still reliant on the implementation of extensive noise controls during specific mining scenarios, such as operating a reduced mining fleet during night time mining and overburden removal, and maintaining significant noise bunds around the WCP.*

A comparison of the 2013 noise model submitted as part of the PER with the updated 2018 noise model submitted with the Application indicates that larger (and noisier) equipment items are now being proposed, which has seen the sound power level significantly increase for key equipment items (e.g. haul trucks, excavator, loaders). Due to these changes, the levels of noise predicted are also significantly increased. The Licence Holder has indicated the mining schedule has increased from the 2013 proposal, and therefore larger equipment items are required.

The noise controls specified in Table 8 are consistent with the operation of similar mineral sands mines on the Swan Coastal Plain, and are not considered to be overly onerous. The key control relates to the suspension of specific operations where there is a risk of noise not complying with the Noise Regulations. The onus is therefore on the Licence Holder to use available tools (e.g. monitoring) and experience to mitigate the risk.

The original noise assessment conducted under the works approval indicated that reducing the sound power level of haul trucks would be key to achieving compliance with the Noise Regulations, in which the Licence Holder committed to retrofitting a noise reduction package ("Hushpak") to the haul trucks and excavators. The Licence Holder investigated a range of "Hushpak" options, however noted no discernible difference between the noise levels with or without noise attenuation (Herring Storer, 2018). This confirms DWER's initial view that this type of noise attenuation would not significantly reduce noise emission levels.

September 2019 amendment: *The requirement to operate the FPP in-pit (below ground level) has been removed following an update to the noise model which indicates noise compliance can be achieved with the FPP operating at natural ground level whilst situated behind existing waste dump bunds. An operational control has also been imposed to require a reduction of fleet numbers during easterly wind conditions (max. 3 haul trucks operating at surface) whilst conducting mining activities at night in Pit B, to address marginal exceedances predicted under these meteorological conditions at the closest receptor west of the Brand Hwy.*

The Licence Holder has also submitted updated noise modelling for future mining operations in the southern portion of the site (Pit C – Stage 2, and Pit D). As the noise model predicts significant noise compliance issues for night-time mining operations at the closest receptor off Aurisch Rd, the Delegated Officer has determined to impose a new control on the licence that restricts night-time mining operations in these pits, unless it can be demonstrated this receptor is not 'noise sensitive' (i.e. a private agreement is in place).

9.1.7 Acid Sulfate Soils controls

The following controls have been specified in the Licence (Condition 10) to mitigate potential

impacts on groundwater quality from the disturbance of ASS:

- Screening – field testing of pH must be conducted during mine path drilling, and biannual laboratory testing for pH_{FOX} to be conducted on random samples of different colours and textures;
- Monitoring of dewatering effluent, including trigger values and subsequent management actions;
- Specified treatment of identified reactive overburden and ore; and
- Actions to be taken in response to exceedances of groundwater trigger values.

Note: *The requirements specified in Table 9 of the Licence generally replicate the management measures proposed by the Licence Holder in the Application, however more detail has been added. The testing regime for PASS has been expanded on to that proposed by the Licence Holder.*

Grounds: *A review of the ASS Investigation Report (SWC, 2017) for the project indicates the presence of PASS within the mine pit boundary, predominantly identified in the overburden, ore and associated product.*

The ASS controls specified in Table 9 are consistent with the operation of similar mineral sands mines on the Swan Coastal Plain and are not considered to be overly onerous. The key controls relate to proactive screening of material in advance of the mine path, and early intervention and treatment of identified PASS. The onus is therefore on the Licence Holder to use available tools (e.g. monitoring) and experience to mitigate the risk.

9.1.8 Monitoring general

A number of conditions have been applied to the Licence (Condition 11 – 14) to prescribe the minimum monitoring requirements. They relate to the minimum requirements for sampling and analysis of samples, minimum timeframes for sampling frequency, and calibration requirements for instruments used by the Licence Holder.

Grounds: *The requirements specified above are to ensure sampling is conducted in a manner that is consistent with accepted standards, procedures and processes.*

9.1.9 Ambient environmental monitoring

Monitoring of ambient noise levels, air quality (dust) and groundwater quality have been specified in the Licence (Conditions 16 – 20), requiring:

- Monitoring of air quality at the location closest to the active pit;
- Monitoring of groundwater quality in the vicinity of mine pits;
- Monitoring of noise levels at the location closest to the active pit;
- Actions to be taken in response to Reportable Events for air quality; and
- Actions to be taken in the event of a noise exceedance.

Note: *The Licence Holder has proposed to conduct monitoring of noise and dust – the requirements specified above expand on the scope relative to the risk of off-site impacts. Groundwater monitoring is proposed to be implemented after mining commences, in parallel with the programme under the Groundwater Operating Strategy.*

Grounds: *In consideration of the nearest BoM weather station, being 25 km south at Gingin Aero, more accurate, site specific wind data should be used to develop a reliable weather forecasting tool (for managing noise and dust), and for use in investigations into potential exceedances.*

Noise and dust

In consideration of the potential for off-site impacts from noise emissions and fugitive dust, monitoring of noise and dust during mining operations is critical for providing assurance over the effectiveness of management controls at the Premises. This includes continuous

monitoring of PM_{10} and noise levels, and weekly monitoring of TSP (24 hours), at the "central west" monitoring location. Internal trigger levels are to be set for each parameter, with alerts sent to the mine supervisor if trigger levels are reached, which will enable early identification and proactive management.

In order to establish if an exceedance of the Noise Regulations is attributed to the Premises, the Licence Holder must conduct an investigation to determine the root cause and any common or contributory factors.

***August 2019 amendment:** the Licence Holder requested a change in the methodology listed for measuring PM_{10} at the Premises, as the monitoring equipment they have in place (Dust Trak) does not comply with any current Australian Standard methodology, and other methods such as using a TEOM or BAM, require a 240V power supply and air conditioning and are therefore not practical for the site. The Licence Holder therefore has proposed to use the HiVol sampler, which is also used for measuring TSP (or PM_{50}), with a size selective inlet for PM_{10}, as this complies with Australian Standard (AS/NZS 3580.9.6). This method does not provide continuous logging – the filters require changing every 24 hours. The Delegated Officer considers this change in methodology will achieve a similar outcome and has therefore updated the licence to reflect this.*

Groundwater quality

Monitoring of shallow groundwater in the vicinity of each mine pit will enable early detection and proactive management of changes in groundwater quality. Monthly monitoring of standard physical parameters (SWL, pH, EC and redox potential) will be conducted as part of the GOS. Additional parameters include major ions, total acidity and alkalinity, and metals and metalloids to be measured on a six-monthly basis.

***August 2019 amendment:** the Licence Holder requested a change to the ambient groundwater monitoring requirements, as half of the 16 monitoring bores specified on the licence are dry, and it has been identified that several nested bores are measuring the same aquifer. The Licence Holder therefore proposed to conduct monitoring in a more targeted approach, where monitoring would be conducted in the vicinity of each mine pit only whilst mining is occurring in that location, and then on an annual basis post-mining in that area. The Delegated Officer has considered this change and has determined the following:*

- *ongoing monitoring of groundwater quality is critical – it should be conducted before mining takes place, during mining and continue post-mining in order to track changes on water quality and to ensure that long-term water quality trends can be assessed. Such monitoring should be conducted across the entire premises, and not be just focused in the immediate vicinity of the current mining area.*
- *annual monitoring is sufficient for metals and metalloids, however other physical parameters linked to ASS must be conducted at least monthly during mining and quarterly post-mining;*
- *the groundwater monitoring schedule should include at a minimum monthly monitoring of one bore upgradient (background) and two bores downgradient of any mine pit during mining and post-mining;*
- *the licence has therefore been amended to require monitoring on a biannual (6-monthly) basis in areas that are yet to be mined, however this frequency is increased to monthly or quarterly following the commencement of mining in that area; and*
- *in order to reduce the cost of monitoring, the licence has been amended to allow monitoring of acidity and alkalinity in the field.*

9.1.10 Record keeping

A number of conditions have been applied to the Licence (Conditions 21 – 24) to prescribe the minimum record keeping requirements. They relate to the standards for book-keeping and the requirement to produce records to the CEO upon request.

In addition, the Licence Holder is required to submit an annual environmental report, containing a summary of all monitoring conducted during the previous annual period.

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

9.1.11 Complaints

The recording of complaints has been specified in the Licence (Condition 23), to ensure the Licence Holder implements a suitable complaints management procedure.

Grounds: *The requirements specified above are necessary to document all complaints received by the Licence Holder, and to demonstrate that each complaint has been sufficiently addressed.*

9.1.12 On-site waste disposal

August 2019 amendment: *the Licence Holder requested the addition of Category 63 (inert landfill site) on the licence, to allow the disposal of inert wastes and used tyres on the Premises.*

The Delegated Officer notes the mine site is within proximity to numerous alternative options at nearby licensed waste recycling and disposal facilities.

The Delegated Officer recognises that on occasion the site may generate wastes that cannot reasonably be reused or recycled, and the Licence Holder may consider it more practicable for on-site disposal rather than off-site disposal. The following controls have therefore been imposed on the licence to permit the on-site disposal of small amounts of inert wastes that meet the following criteria:

- *on-site waste disposal is restricted to non-mining wastes that are of an inert nature, such as construction and demolition wastes that are unsuitable for reuse or recycling (in line with the State Government's Waste Avoidance and Recovery Strategy 2030);*
- *off-site wastes must not be accepted onto the Premises for disposal;*
- *waste must be disposed by burial within the specified area in the mine void;*
- *waste must be disposed at least 2 metres above the highest known water table;*
- *alternatives exist for the disposal of used light vehicle tyres at existing tyre monofils, where they can be readily recovered – as such these are not permitted for on-site disposal (heavy vehicle tyres permitted for disposal where it can be demonstrated that it is not practical to recycle); and*
- *disposal of 'special' types of inert waste that are unlikely to be generated from on-site activities, such as asbestos, biomedical wastes, biosolids, etc., are not permitted for on-site disposal.*

The Delegated Officer considers the addition of Category 63 is not required on the licence, as the proposed activity does not meet the definition of an inert landfill site (i.e. the Licence Holder is proposing to dispose of non-mining waste generated on the Premises within the mine void, opposed to operating an inert landfill site where waste is accepted onto the Premises for disposal).

10. Determination of Licence conditions

The conditions in the issued Licence in Attachment 1 have been determined in accordance with the *Guidance Statement: Setting Conditions*.

The *Guidance Statement: Licence Duration* has been applied and the issued licence expiry has been set to align with expiry of tenement M70/1311 (11/03/2034).

11. Licence Holder's comments

The Licence Holder was provided with the original draft Decision Report and draft Licence on 19 November 2018. The Licence Holder provided comments which are summarised, along with DWER's response, in Appendix 2.

August 2019 amendment: The Licence Holder was provided with the amended drafts on 13 August 2019 and made no additional comments.

September 2019 amendment: The Licence Holder was provided with the amended drafts on 13 September 2019 and made no additional comments.

12. Conclusion

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

The original assessment was also informed by a site visit by DWER officers on 22 October 2018.

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

Tim Gentle

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Tim Gentle
MANAGER, RESOURCE INDUSTRIES
REGULATORY SERVICES

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

Appendix 1: Key documents

	Document title	In text ref	Availability
1.	Bureau of Meteorology, 2018. Climate Data Online – Climate Statistics: Gingin Aero (009178)	BOM, 2018	accessed at:
2.	Boonanarring Project – Environmental Licence Application supporting document. Image Resources NL (17 August 2018).	Application	DWER records (A1729074)
3.	Boonanarring Project – Works Approval Application supporting document. Prepared for Image Resources NL by Preston Consulting Pty Ltd (2 June 2017).	Works Approval Application	DWER records (A1449925)
4.	COOE, May 2015. *Detailed Operating Strategy – Boonanarring Mineral Sands Project*. Prepared for Image Resources NL by COOE Pty Ltd.	COOE, 2015	DWER records (A1738414)
5.	DER, June 2015. *Identification and investigation of acid sulfate soils and acidic landscapes*. Department of Environment Regulation, Perth.	DER, 2015c	accessed at www.der.wa.gov.au
6.	DER, June 2015. *Treatment and management of soils and water in acid sulfate soil landscapes*. Department of Environment Regulation, Perth.	DER, 2015d	
7.	DER, July 2015. *Guidance Statement: Regulatory principles.* Department of Environment Regulation, Perth.	DER, 2015a	
8.	DER, October 2015. *Guidance Statement: Setting Conditions.* Department of Environment Regulation, Perth.	DER, 2015b	
9.	DER, November 2016. *Guidance Statement: Environmental Siting*. Department of Environment Regulation, Perth.	DER, 2016	
10.	DER, February 2017. *Guidance Statement: Risk Assessments*. Department of Environment Regulation, Perth.	DER, 2017a	
11.	DER, February 2017. *Guidance Statement: Decision Making*. Department of Environment Regulation, Perth.	DER, 2017b	
12.	DMP, May 2015. *Guidelines for Preparing Mine Closure Plans*. Department of Mines and Petroleum, Perth.	DMP, 2015a	accessed at www.dmp.wa.gov.au
13.	DMP, October 2015. *Mining Act Guidelines – Basic Provisions*. Department of Mines and Petroleum, Perth.	DMP, 2015b	
14.	Herring Storer Acoustics, May 2018. Acoustic report – mobile equipment – mineral sands minesite, Gingin – External noise tests. Prepared for Image Resources NL by Herring Storer Acoustics	Herring Storer, 2018	DWER records (A1738394)
15.	Lloyd George Acoustics, June 2013. *Environmental Noise Assessment: Boonanarring Mineral Sands, Gingin*. Prepared for Image	LGA, 2013	DWER records (A1738406)

	Resource NL by Lloyd George Acoustics Pty Ltd.		
16.	Lloyd George Acoustics, March 2017. *Environmental Noise Assessment: Boonanarring Mineral Sands, Gingin*. Prepared for Image Resource NL by Lloyd George Acoustics Pty Ltd.	LGA, 2017a	DWER records (A1738422)
17.	Lloyd George Acoustics, October 2017. *Memo – Boonanarring Mineral Sands – All Bunds Noise Modelling*. Prepared for Image Resources NL by Lloyd George Acoustics.	LGA, 2017b	DWER records (A1738392)
18.	Lloyd George Acoustics, October 2018. *Environmental Noise Assessment: Boonanarring Mineral Sands, Gingin*. Prepared for Image Resource NL by Lloyd George Acoustics Pty Ltd.	LGA, 2018	DWER records (A1738436)
19.	Lloyd George Acoustics, August 2019. *Environmental Noise Assessment: Boonanarring Mineral Sands, Gingin. Report: 17023882-10B model update*. Prepared for Image Resource NL by Lloyd George Acoustics Pty Ltd.	LGA, 2019	DWER records (A1822250)
20.	Ministerial Statement 981	MS 981	accessed at www.epa.wa.gov.au
21.	Preston Consulting, July 2017. *Boonanarring Project – Noise Management Plan*. Prepared for Image Resource NL by Preston Consulting Pty Ltd.	Preston Consulting, 2017	DWER records (A1532666)
22.	Preston Consulting, May 2018. *Revised Mining Proposal: Boonanarring Project*. Prepared for Image Resources NL by Preston Consulting Pty Ltd.	Preston Consulting, 2018a	accessed at minedexext.dmp.wa.gov.au
23.	Preston Consulting, May 2018. *Mine Closure Plan: Boonanarring Project – Rev3*. Prepared for Image Resources NL by Preston Consulting Pty Ltd.	Preston Consulting, 2018b	
24.	Report and recommendations of the Environmental Protection Authority – Boonanarring Mineral Sands Mine, Image Resources NL (June 2014).	EPA Report 1516	accessed at www.epa.wa.gov.au
25.	Soilwater Consultants, April 2017. *Boonanarring ASS Investigation*. Prepared for Image Resources NL by Soilwater Consultants Pty Ltd.	SWC, 2017	DWER records (A1738410)
26.	URS, July 2013. *Report – Boonanarring Project: Surface Water Studies*. Prepared for Image Resources NL by URS Australia Pty Ltd.	URS, 2013a	DWER records (A1738408)
27.	URS, August 2013. *Report – Boonanarring Project: H3 Hydrogeological Assessment*. Prepared for Image Resources NL by URS Australia Pty Ltd.	URS, 2013b	DWER records (A1738418)
28.	URS, November 2013. *Report – Boonanarring Project: Addendum to H3 Hydrogeological Assessment*. Prepared for Image Resources NL by URS Australia Pty Ltd.	URS, 2013c	DWER records (A1738421)

29.	USGS, October 1999. *Environmental characteristics of clays and clay mineral deposits*. U.S. Geological Survey, Reston, Virginia, United States.	USGS, 1999	accessed at: pubs.usgs.gov/info/clays/clays.pdf
30.	Works Approval W6065/2017/1 – Boonanarring Mineral Sands Mine	W6065/2017/1	accessed at: www.dwer.wa.gov.au
31.	360 Environmental, October 2013. *Boonanarring Mineral Sands – Level 2 Flora and Vegetation and Groundwater Dependent Vegetation Survey*. Prepared for Image Resource NL by 360 Environmental Pty Ltd.	360 Environmental, 2013	DWER records (A1738431)

Appendix 2: Summary of Licence Holder's comments on risk assessment and draft conditions

Condition	Licence Holder comment	DWER response
Table 3 – solar drying ponds	Solar drying ponds are also located off-path.	The two off-path ponds constructed under W6065 are the only ponds located off-path – the requirement to located solar ponds on-mine path is for new ponds only.
	The slope of the pond floor is constructed to allow for any runoff water to be collected.	DWER acknowledges that due to the non-linear shape of solar ponds, that it will not be practical to apply a single, standardised pond floor slope to enable draining and collection of supernatant water.
	The specification of containing a fines content of <30% cannot be met.	DWER acknowledges that due to the lack of clay in the first few years of operation that this requirement is not practicable, and that consolidation of the first layer of slimes will provide a natural barrier to groundwater.
Table 4 – mining unit	As per the noise modelling, the mining unit has been modelled as point sources 1 m above ground level. The FPP will therefore be located as per the noise model.	The noise model is based on the mining unit being located on a pad and situated at least 10 m below the natural ground level. The notation in the model regarding 1 m above ground level relates to fixed plant such as pumps, etc. at the process plant.
Table 4 – pipelines carrying HMC	Pipelines running from the WCP to the HMC stockpile are directly downgradient from the WCP, where any spills/leaks will be contained within the WCP stockpile area that comprises an underdrainage system.	Noted, the requirement to locate HMC pipelines within service corridors has been removed.
Table 4 – pipelines carrying clay fines and return water	Pipelines will be placed where topsoil and subsoil has been removed, but are not 300 mm below ground level.	Noted, the condition has been changed to reflect that pipelines will be located within service corridors, where it is understood that any spills/leaks will be contained within the active area.
Table 6 – clay slimes	Image requests the ability to utilise clay fines as dust suppressant.	Condition has been amended to allow fines to be used for dust suppression within the Premises.
Condition 11(f)	Collection of PM_{10} samples in accordance with AS3580.9.8 or AS3580.9.11 – Image currently uses DustTrak monitors to continuously measure PM_{10}, which do not comply with these AS.	As dust is high risk at this site, DWER requires accurate measurements of PM_{10} using instrumentation that complies with relevant Australian Standards. Whilst DustTrak is good for providing fast indicative data, it is not consistent with AS or W6065.
Table 14 – groundwater bores	The bores listed in the draft licence appear to be the opposite if those listed in W6065. Some of the bores listed in the draft have loggers and are being monitored as part of MS conditions.	Noted, the list of bores has now been rectified and updated to include the two new bores installed under W6065.

Attachment 1: Amended Licence L9177