# Decision Report

## Review of Existing Licence

**Division 3, Part V *Environmental Protection Act 1986***

| | |
|---|---|
| **Licence number** | L5319/1988/12 |
| **Licence holder** | Tronox Management Pty Ltd |
| **ACN** | 009 343 364 |
| **File number** | DER2015/000793 |
| **Premises** | Cooljarloo Mineral Sands Mine<br>12051 Brand Highway<br>COOLJARLOO WA 6507<br><br>Legal description –<br>Mining Lease M70/268A |
| **Date of report** | 23 December 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 |
| ADWG | Australian Drinking Water Guidelines |
| AHD | Australian Height Datum |
| ASS | Acid Sulfate Soils |
| BAC | Billinue Aboriginal Community |
| category/ cat | Categories of prescribed premises as set out in Schedule 1 of the EP Regulations |
| CS Act | *Contaminated Sites Act 2003* (WA) |
| DBCA | Department of Biodiversity, Conservation and Attractions |
| decision report | refers to this document |
| delegated officer | an officer under section 20 of the EP Act |
| Department | means the department established under section 35 of the *Public Sector Management Act 1994* and designated as responsible for the administration of Part V, Division 3 of the EP Act |
| DMIRS | Department of Mines, Safety and Industry Regulation |
| DWER | Department of Water and Environmental Regulation |
| EIL | Environmental Investigation Level |
| EMP | Cooljarloo Environmental Management Programme |
| EPA | Environmental Protection Authority |
| EP Act | *Environmental Protection Act 1986* (WA) |
| EP Regulations | *Environmental Protection Regulations 1987* (WA) |
| EPBC Act | *Environment Protection and Biodiversity Conservation Act 1999* (Cth) |
| ERMP | Environmental Review and Management Program |
| ESD | Environmental Scoping Document |
| existing licence | refers to the Licence issued under Part V, Division 3 of the EP Act and in force prior to the commencement of, and during this Review |
| GDE | Groundwater Dependent Ecosystem |
| GL | gigalitre, a unit of volume equivalent to $10^9$ litres |
| GOS | Groundwater Operating Strategy |
| ha | hectare |
| HMC | Heavy Mineral Concentrate |
| JTSI | Department of Jobs, Tourism, Science and Innovation |
| LEAF | Leaching Environmental Assessment Framework |
| licence holder | Tronox Management Pty Ltd |
| $m^3$ | cubic metres |
| mbgl | metres below ground level |
| Mineral Residue Facility/ MRF | refers to the area on the Premises that has been used for the disposal of tailings and other production wastes generated from downstream processing and refining of the mined sands (a.k.a. “mineral processing |

| | |
|---|---|
| | residues") |
| Mining Act | *Mining Act 1978 (WA)* |
| Minister | the Minister responsible for the EP Act and associated regulations |
| MS | Ministerial Statement |
| MSARCC | Mineral Sands Agreement Rehabilitation Coordinating Committee |
| Mtpa | Million tonnes per annum |
| NAE | Neutralised Acid Effluent |
| NEPM | National Environmental Protection Measure |
| NORM | Naturally Occurring Radioactive Material |
| Noise Regulations | *Environmental Protection (Noise) Regulations 1997* (WA) |
| occupier | has the same meaning given to that term under the EP Act |
| PASS | Potential Acid Sulfate Soils |
| PER | Public Environmental Review |
| $pH_F$ | field pH |
| $pH_{FOX}$ | field pH peroxide |
| 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 |
| PSI | Preliminary Site Investigation |
| RCWA | Radiological Council of Western Australia |
| review | this licence review |
| revised licence | the amended licence issued under Part V, Division 3 of the EP Act following the finalisation of this Review |
| risk event | As described in *Guidance Statement: Risk Assessment* |
| RIWI Act | *Rights in Water and Irrigation Act 1914 (WA)* |
| RMP | Radiation Management Plant |
| RWMP | Radiation Waste Management Plan |
| SR | Synthetic Rutile |
| SRE | Synthetic Rutile Effluent |
| State Agreement | *Mineral Sands (Cooljarloo) Mining and Processing Agreement Act 1988* |
| TAA | Total Actual Acidity |
| TPA | Total Potential Acidity |
| TDS | Total Dissolved Solids |
| tpa | tonnes per annum |
| tph | tonnes per hour |
| UCL | Unallocated Crown Land |
| USEPA | U.S. Environmental Protection Agency |
| $\mu g/m^3$ | micrograms per cubic metre |
| µg/L | micrograms per litre |
| WCP | Wet Concentrator Plant |

## 2. Purpose and scope of assessment

The Department of Water and Environmental Regulation (DWER) has determined to review licence L5319/1988/12 issued to Tronox Management Pty Ltd (the licence holder) under Division 3, Part V of the *Environmental Protection Act 1986* (EP Act) for the Cooljarloo Mineral Sands Mine (the Premises).

The review forms part of DWER's program of risk-based licence reviews, and was initiated to ensure accuracy and adequacy of conditions with respect to emissions and discharges from on-site activities. The licence holder was formally notified of the review on 30 September 2016.

This decision report sets out the delegated officer's assessment of risks arising from a review of emissions and discharges generated by the primary activities conducted at the Premises. It also includes a risk assessment of a proposal to extend the Mineral Residue Facility (MRF).

## 3. Background

The Premises is a large-scale heavy mineral sands mine located around 175 km north of Perth on the northern Swan Coastal Plain. It forms part of an integrated titanium minerals project, which also involves downstream mineral separation and processing at plants located near Muchea (Chandala) and in Kwinana.

The integrated project was initially operated as a joint venture between South African mining company Exxaro Resources Ltd (Exxaro) and American titanium dioxide pigment producer Tronox Ltd (Tronox), and was known as the 'Tiwest Joint Venture'. In 2011, Tronox acquired Exxaro's interest in the joint venture and it was relabelled as 'Tronox Management Pty Ltd'.

The original mining proposal was formally assessed in 1987 by the Environmental Protection Authority (EPA) as an Environmental Review and Management Program (ERMP). The proposal was approved under Ministerial Statement (MS) 37 and mining commenced at the site in 1989, pursuant to the *Mineral Sands (Cooljarloo) Mining and Processing Agreement Act 1988* (State Agreement).

Activities at the Premises comprise heavy mineral extraction via dredge mining, although conventional dry mining techniques have been used in the past. Mining initially commenced as a dredging operation on the company-owned Mullering Farm, with a dry mining operation commencing in 1997 to supplement feed to the dredging concentrator. Dry mining became a free-standing operation in 1999 following construction of a dedicated land-based concentrator. Target minerals include ilmenite, zircon, rutile and leucoxene, which is hosted in multiple strand lines paralleling the Gingin Scarp that forms the eastern edge of the Swan Coastal Plain.

Two extensions to the original mine footprint have subsequently been approved by the Minister for Environment (Minister) through separate MS (refer to section 5.1). Mining of both extensions has been completed and these sites are currently being rehabilitated.

The prescribed premises category that the revised licence is subject, as defined in Schedule 1 of the *Environmental Protection Regulations 1987* (EP Regulations), is described in Table 2.

**Table 2: Prescribed premises category in the revised licence**

| Classification of Premises | Description | Approved Premises throughput |
|---|---|---|
| Category 8 | Mineral sands mining or processing: premises on which mineral sands ore is mined, screened, separated or otherwise processed. | 810,000 tonnes per annual period |

# 4. Overview of Premises

The mine has operated within State Agreement Mining Lease 70/268 (M268SA) since 1989. The lease is approximately 9,744 hectares (ha) in total area and comprises the company-owned Mullering Farm (1,035 ha), two third party freehold lots (14 ha and 13 ha), and the remaining 8,651 ha is undisturbed Unallocated Crown Land (UCL) (Figure 1).

Over time the mine has evolved as two separate operations – the 'north' mine and 'south' mine. The 'south' mine involves a large dredging operation and is currently the sole active mining operation on the Premises. The 'north' mine involved a separate dry mining operation, which concluded in December 2015, and the area will be dredged from 2020 to 2024.

Ore is currently mined with tandem dredges, dredging the ore which is then pumped via pipeline to a floating wet concentrator plant (WCP), where the sand fraction and clay fines are removed and the heavy minerals concentrated using wet gravity separation on spirals. Sand tailings rejects are deposited at the rear of the dredge pond, while the clay fines are initially deposited at the rear of the dredge pond, where the material is allowed to settle and concentrate at the base, prior to being pumped to specially constructed ponds for solar drying.

The heavy mineral concentrate (HMC) is pumped to a land-based stockpile where it is drained in preparation for transportation by road to the company's mineral separation plant and synthetic rutile metallurgical complex at Chandala for further processing. Annual tonnages peaked around 800,000 tonnes in the early to mid-2000s, however production has more than halved in recent years.

Waste residues generated during the downstream processing of HMC are returned to the Premises for disposal at the 'Mineral Residue Facility' (refer to section 4.1.6). An average of 400,000 tonnes per annum (tpa) has been transported by road from the Chandala and Kwinana plants for disposal since the commencement of operations.

## 4.1 Operational aspects

The heavy mineral deposits have been extracted by either dredge or dry mining, with the method determined by the grade of ore and/or the position of a deposit relative to local groundwater levels.

Dredge mining typically involves mining lower grade ore (<7% HMC) deeper in the profile and below the water table, while dry mining has involved mining the higher grade (typically 8 – 12% HMC) shallower ore bodies.

### 4.1.1 Dredge mining

Dredge mining initially involves removing the top 5 – 20 m of overburden to expose the orebody situated below the water table. Ore is then mined using tandem dredges that deliver slurried ore to a floating WCP, which in turn recovers heavy mineral by means of wet gravity separation.

The dredge floats in a pond created by initial groundwater flow into the void following ore and overburden removal. It utilises a cutting head to disturb the ore, which is then slurried and pumped via a floating pipeline to the WCP situated behind the dredge.

The main dredge, Cooljarloo I, is capable of mining up to 25 m below the water surface. A secondary dredge, Pelican, can mine up to 15 m depth and is typically used to mine a bench in advance of the main dredge. The depth is generally maintained between 22 and 25 m, which provides the most operational flexibility for changes in the level of the base of the orebody.

The size of the dredge pond is maintained between 45 and 80 ha (currently 77 ha), mainly to allow settling of suspended material away from the active dredging area.

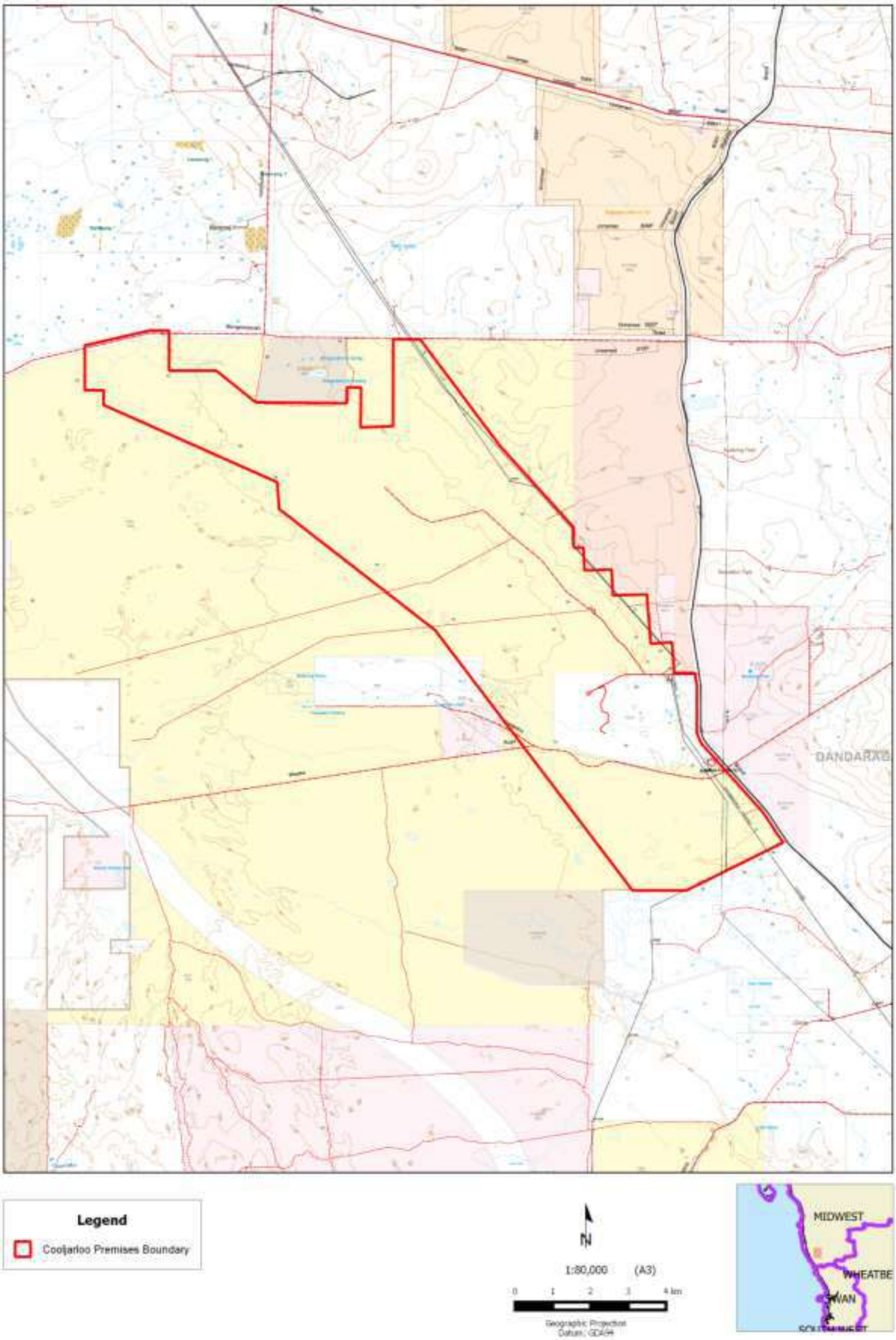


***Figure 1: Location of Cooljarloo Mineral Sands Mine.***

### 4.1.2 Dry mining

During dry mining operations, conventional heavy earthmoving equipment (i.e. bulldozer, scraper, front end loader) was used to expose the orebody and to push material into an in-pit hopper, a method known as 'dozer trap mining'.

The ore was initially screened to remove oversize material (greater than 150 mm), prior to injection with water to create a slurry, which was then pumped to a trommel to remove material greater than 3 mm in size. The remaining ore was pumped up to 3 km to a land-based WCP, where the slurried ore was upgraded to HMC using separation processes similar to those employed in the floating WCP servicing the dredges.

### 4.1.3 Heavy mineral recovery

The heavy minerals in the screened and slurried ore, which includes the valuable titanium minerals and zircon, are recovered in the WCP. The ore is passed through a series of gravity spirals where the heavy minerals with specific gravities >3.5 flow to the inside of the spirals and are separated from the principal waste mineral, quartz, which has a specific gravity <3 and travels towards the outside of the spirals.

The current processing capacity of the 'south' mine concentrator is 4,200 tonnes per hour (tph), which is significantly greater than the land-based 'north' mine concentrator (650 tph).

The HMC is then pumped to a land-based stockpile and excess water allowed to drain, prior to transport to the Chandala complex for further processing.

### 4.1.4 Tailings management

Tailings material from the production of HMC comprises waste sands, clays and heavy minerals (quartz, kaolinite, goethite and ilmenite).

#### Dredge mining

After the ore has been processed and the heavy mineral removed, the tailings are deposited at the rear of the dredge pond. When initially establishing a dredge pond and to maintain a pond of adequate area, tailings have been disposed to external tailings storage facilities.

Approximately 4% of the tailings material in the dredging operation are classed as fines (less than 63 microns), which are dominated by the mineral kaolinite. In response to acid sulfate soil (ASS) issues (refer to section 7.1), once settled in the dredge pond, the residual clay fraction is transferred to tailings storage facilities, herein referred to as solar drying dams. These dams are typically constructed within previous mine voids or on the current mine path (also known as 'on-mine-path'). On deposition a portion of the water in the slurry separates, decants off and is collected and returned for reuse. Once dried, the dams are either removed prior to mining, or decommissioned and land-formed (covered with a layer of sand tailings) to become part of the rehabilitated soil profile.

#### Dry mining

During dry mining, a thickener was used to separate the sand tailings from the clay fines, with a polyacrylamide flocculant (Flopam AN923) used to assist with separation. The clay fines fraction was then pumped to solar drying dams at an average solids content of 25%, drying to approximately 95% solids (dry bulk density = 1.5).

Overburden, in combination with sand tailings, was used to backfill mined-out areas. Sand tailings were pumped at an average solids content of 40%, and settle to an estimated final dry bulk density of 1.5 t/m$^3$.

#### Pipeline network

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

- HMC from the WCP to the HMC stockpile;
- Water recovered from HMC stockpile back to the dredge pond;
- Clay fines to the solar drying dams;
- Supernatant water from the solar drying dams to the return water pond; and
- Sand tailings to tailings storage facilities (dry mining).

Pipelines are placed within service corridors that are approx. 10 m wide and generally located between a light vehicle road and a powerline corridor, to ensure that solids from any spills or leaks due to pipeline failures are contained (and water allowed to soak into the sandy soil). All pipelines are placed away from surface waters, and if unavoidable, higher specification lines are used, e.g. steel or double-lined pipe.

### 4.1.5 Mine water management

Large volumes of groundwater are used to establish and maintain water levels in the dredge pond, transport ore in a slurry and for the separation of HMC from sand tails. A large portion of the water is returned to the aquifer via seepage through the dredge pond and solar drying dams. A conceptual schematic of the mine water circuit is shown in Figure 2.

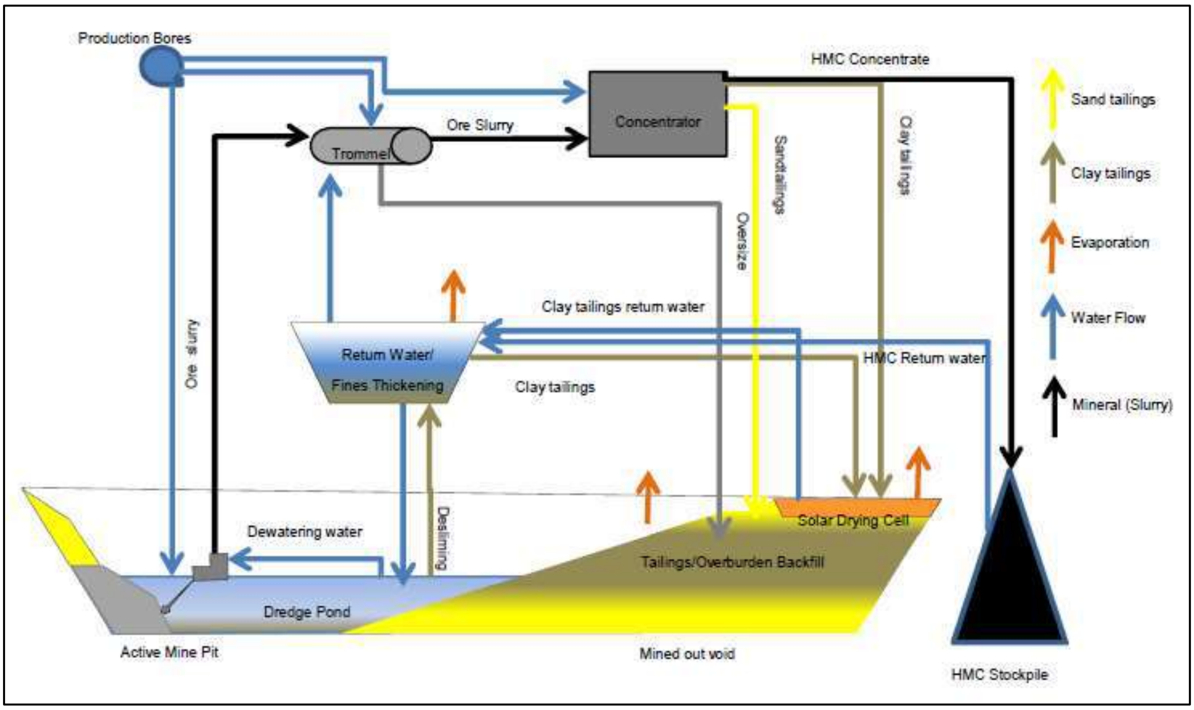


***Figure 2: Mine water circuit for the dredging operation.***

#### Dredge pond

Water levels within the dredge pond are maintained by natural groundwater flowing in from the surrounding water table. Water losses due to ore removal and evaporation are supplemented from nearby abstraction bores, return water from solar drying ponds and recycled water from the HMC stockpile.

Ore is dredged and pumped as a slurry via a floating pipeline to the WCP situated behind the Dredge in the pond. The ore slurry is firstly screened through a trommel using return water to remove oversize material before being pumped to the WCP.

#### Wet Concentration Plant (WCP)

Process water used at the WCP is obtained from the dredge pond, nearby abstraction bores and return water. It is used to separate out the clay fines through a series of hydrocyclones, which are pumped to solar drying dams where the entrained water is either lost as seepage through the base of the dam or through evaporation after the solids settle. The supernatant water is recovered and pumped to the return water ponds for reuse. The remaining ore is then upgraded to HMC by using process water to separate out sand tailings and any remaining clay through a series of gravity spiral circuits.

### Process water ponds

The advancing mining operations require water holding ponds in central locations to provide clean water for processing. Water holding ponds generally have low external activities and no direct inflows of sand tailings, clay fines or dirty water (e.g. cyclone overflow water).

The water holding ponds are temporary in nature and created 'on-mine-path'. The natural lining properties of the clay fines are used to contain the water – as the mine path progresses these ponds are either removed prior to mining, or converted to solar drying dams.

### Supernatant and surface water management

Water released from the deposited tailings (supernatant) is returned to a water reclamation pond with pumps, siphons, overflow decant pipes or, as in most cases, with a gravity decant system consisting of polyethylene pipeline and weir box fitted with adjustable boards to control rising water levels.

The majority of surface water on the Premises infiltrates due to the sandy nature of the soil. The main focus of surface water control is around preventing runoff into Mullering Brook from the 'Mineral Residue Facility' (refer to section 4.1.6).

## 4.1.6 Mineral Residue Facility

The MRF, previously known as the 'Black Waste Dump', refers to an area within Mullering Farm that has been used for the disposal of waste residues generated from downstream processing and refining of the mined sands at Chandala and Kwinana. These waste materials are collectively known as 'mineral processing residues' (previously known as 'black waste').

### Description

The MRF comprises a number of waste pits of varying sizes and shapes that have been progressively backfilled since dumping commenced in 1993. The current active area forms part of what is known as 'Pit 7', which includes an initial cell and two extensions. The initial cell and first extension are known as 'Phase 1' and have been completed and covered with a capping layer. The second extension, known as 'Phase 2', is the current active disposal area. It covers an area of 14 ha with a design capacity of ~1,000,000 $m^3$ and is expected to reach capacity in 2019. A proposal to construct a new, eighth pit with a design capacity of approx. 3,670,000 $m^3$, has been assessed and approved under this review, which will provide a further 21 years of capacity.

The licence holder intends to operate the MRF beyond the life of the mine (that is assuming an alternative feedstock can supply the Chandala and Kwinana plants).

### Waste streams

A summary of the various waste streams that constitute mineral processing residue, and the quantities disposed per calendar year of operation, is shown in Table 3. Approximately 70% of the waste originates from the Chandala complex, with the remaining 30% from the Kwinana operations.

Tonnages have reduced since 2016 following the cessation of operations at the North Mine and reduced production volumes in response to market conditions. There has not been an SRE filter cake waste stream since a standard grade SR process was implemented at Chandala in 2015.

The existing licence currently permits the disposal of wastes at the MRF other than process tailings, such as material from clean-up, maintenance, decommissioning and/or construction activities, and other inert wastes. This is discussed further in this section under 'Classification'.

**Table 3: Volumes of process waste disposed at the Mineral Residue Facility 1992 – 2017 ($10^3$ tonnes)**

| Waste type | Source site | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Filter cake | Kwinana | 16.7 | 37 | 42.6 | 46.4 | 54.5 | 58.9 | 68.7 | 68.1 | 75.2 | 58.1 | 61.4 | 65.6 | 76.2 |
| White tailings, Screen 1 and 2 oversize | Chandala MSP | 101.2 | 41.7 | 106.6 | 81.7 | 55.6 | 76.3 | 82.0 | 88.6 | 100.9 | 121.3 | 132.1 | 153.5 | 77.8 |
| Coarse rejects | | | | | | | | | | | | | | 49.5 |
| Pre-screening tailings | | | | | | | | | | | | | | 49.5 |
| Filter cake (IO/NAE) | Chandala SR plant | 91.8 | 42.3 | 96 | 149.1 | 127.5 | 72 | 70.5 | 87.9 | 84 | 66.9 | 89.9 | 91.3 | 105 |
| Pugged waste | | 0 | 0 | 0 | 25 | 11.5 | 88.9 | 89.5 | 108.5 | 106.3 | 120.5 | 73.1 | 89.4 | 128.7 |
| Filter cake (SRE) | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 18.2 | 27.2 | 11.2 | 0 | 0 | 0 |
| Waste fines | | 19.7 | 17.8 | 25.6 | 35.5 | 33.8 | 7.8 | 4.3 | 7.1 | 8.2 | 2.1 | 0.9 | 1.4 | 0 |
| Other waste | All | na | na | na | na | na | na | na | na | na | na | na | na | 26.7 |
| **Total** | | **281.4** | **146.4** | **270.8** | **337.7** | **282.9** | **303.9** | **315.0** | **387.4** | **401.8** | **380.1** | **357.4** | **401.2** | **486.7** |

| Waste type cont. | Source site | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Filter cake | Kwinana | 70.5 | 73.5 | 76.1 | 70.8 | 83 | 77.8 | 94.9 | 68.3 | 67.6 | 80.2 | 101.9 | 84.8 | 90.3 |
| White tailings, Screen 1 and 2 oversize | Chandala MSP | 47.5 | 48.8 | 56.4 | 48.8 | 45.5 | 57.3 | 63 | 40.3 | 59.0 | 73.0 | 65.6 | 43.7 | 35.3 |
| Coarse rejects | | 40.9 | 44.3 | 36.2 | 34.5 | 34.5 | 40.6 | 66.9 | 48.4 | 59.1 | 58.1 | 52.0 | 32.5 | 35.5 |
| Pre-screening tailings | | 47.1 | 50.5 | 32.4 | 34.2 | 43.3 | 58.5 | 36.3 | 13.1 | 13.9 | 13.9 | 14.4 | 6.2 | 3 |
| Filter cake (IO/NAE) | Chandala SR plant | 83.4 | 77.4 | 52.8 | 92.8 | 97.9 | 104.8 | 114.8 | 93.7 | 83.5 | 124.3 | 132.8 | 130.6 | 126 |
| Pugged waste | | 133.1 | 118.5 | 139.2 | 121.2 | 67.9 | 40.3 | 54.9 | 94 | 115.3 | 31.7 | 28.6 | 25.8 | 39.4 |
| Filter cake (SRE) | | 14 | 13.1 | 8.4 | 13.3 | 13.6 | 12.3 | 15.5 | 15 | 14.2 | 18.5 | 9.8 | 0 | 0 |
| Waste fines | | 8.3 | 14.9 | 7.4 | 6.3 | 2 | 0.9 | 0.7 | 0.3 | 5.2 | 3.0 | 0.7 | 0.5 | 0.3 |
| Other waste | All | 20.3 | 0 | 0 | 0 | na | 0 | na | 7.5 | 2.5 | 0.6 | 2.3 | 0 | 3.4 |
| **Total** | | **465.2** | **441.1** | **408.8** | **421.7** | **388.6** | **392.4** | **447.1** | **380.6** | **420.8** | **403.4** | **408.1** | **324.2** | **333.1** |

na: data not available or not collected

IO: iron oxide, NAE: neutralised acid effluent, SRE: synthetic rutile effluent

## Waste pit construction methods

According to HGM (1996), the waste pits are constructed in areas where overburden, clay fines and sand tailings have been historically deposited. The earlier pits (1 and 2) were developed over undisturbed overburden whereas later pits have been developed over sections of the dredge pond where clay fines and sand tailings have been deposited and then covered with silty, clayey overburden. The total depth of overburden placement for the earlier pits is generally in excess of 30 m.

The location of the waste pits and groundwater monitoring bores is illustrated in Figure 4. Mining operations have significantly modified the Superficial formation in the immediate vicinity of the waste pits, a schematic cross-section is illustrated in Figure 3.

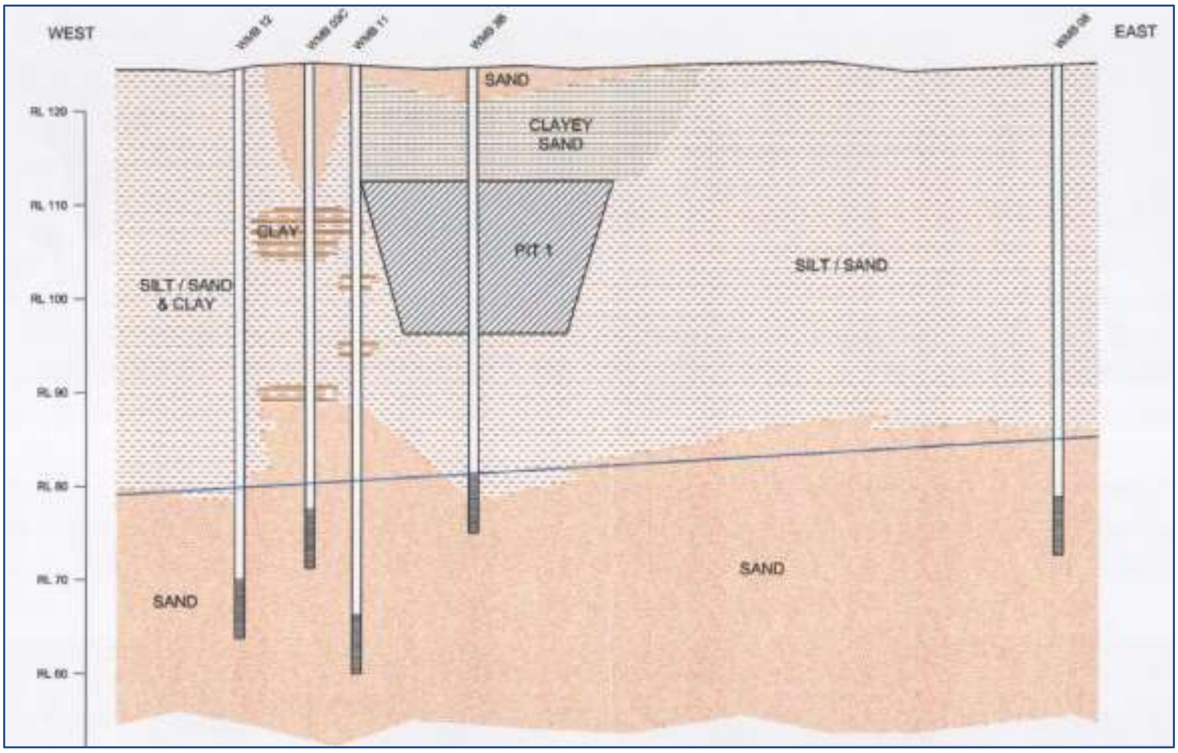


***Figure 3: East-west cross section through Black waste pit 1 (PPK, 2001b)***

As at 2019, a total of seven waste pits have been constructed at the Premises (construction details summarised in Table 4 below). There is no recorded placement of compacted clay floors for pits 1, 2 and 3 – HGM (1996) has assumed they are underlain by clayey overburden and tailings (*Figure 5*). Subsequent pits have both compacted clay floors and walls (*Figure 6*), although the attainment of target permeabilities of $1x10^{-9}$ m/s has not always been possible with the available materials (discussed further below).

The depth to the water table below the pit floors ranges from approximately 20 m at Pits 1 and 2 to 6 m at Pit 7 and this has generally been achieved by the deposition of overburden or tailings following mining activities.

**Key findings:**

1. Separation to groundwater for Waste Pits 6 & 7 (and proposed Cell 8) has been artificially achieved through backfilling over old dredge pond areas using compacted overburden. The geotechnical stability of the final landform is therefore critical in terms of the ongoing integrity of the clay lining system on the pit floors, walls and capping.

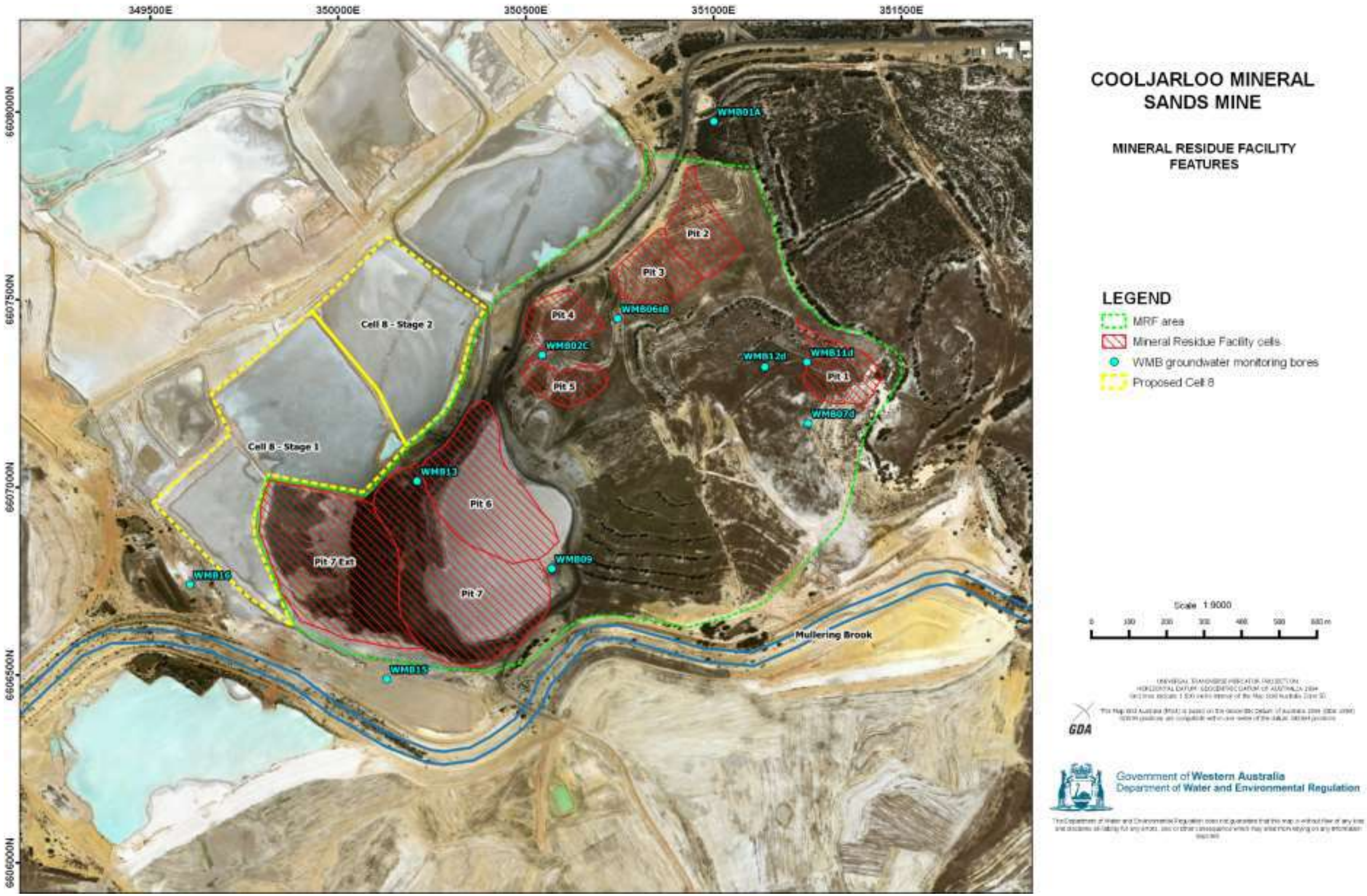


***Figure 4: Location of black waste pits and associated monitoring bores.***

**Table 4: Construction details of MRF pits**

| Waste disposal pit | Year constructed | Decom. | Approx. volume ($m^3$) | Pit floor construction | | | |
|---|---|---|---|---|---|---|---|
| | | | | Material | Thickness | Base of pit | Permeability |
| Pit 1 | Prior to Sept 1991 | Q1 1994 | 300,000 | Cl/ OB | ~20 m | RL 95.5 | $1 \times 10^{-5}$ m/s |
| Pit 2 | 1992 | Q1 1995 | 150,000 | Cl/OB | 22 m | RL 102 | $1 \times 10^{-5}$ m/s |
| Site 3 | Q1 1995 | - | 300,000 | Cl/OB | 17 m | RL 97 | $1 \times 10^{-5}$ m/s |
| Pit 4 | May 1995 | - | 250,000 | Cl/OB + compacted clay | 7.5 m + 1 m compacted clay | RL 84.5 | $1.3 \times 10^{-6}$ to $3.2 \times 10^{-6}$ m/s |
| Site 5 | Dec 1996 | - | 250,000 | | 1 m compacted clay | >RL 83 | $2.19 \times 10^{-7}$ to $1.14 \times 10^{-8}$ m/s |
| Pit 6 | 2003 | 2009 | 700,000 | | | RL 91 | $6.8 \times 10^{-7}$ to $1.2 \times 10^{-10}$ m/s |
| Pit 7 | 2006 | 2012 | 700,000 | | | RL 84 | $1 \times 10^{-9}$ m/s |
| Pit 7 Ext #1 | 2010 | In use | 300,000 | | | RL 85 | $1 \times 10^{-9}$ m/s |
| Pit 7 Ext #2 | May 2013 | In use | 1,040,000 | | 300mm, placed in 2 x 150 mm layers compacted and rolled | RL 85.3 | $1 \times 10^{-9}$ m/s |

| Waste disposal pit (cont.) | Pit walls | Capping | | | Rehab |
|---|---|---|---|---|---|
| | | Yes/No | Thickness | Top of Pit | |
| Pit 1 | Unknown | Yes, clay OB | 2.6 m | 110 to 112 mAHD | Completed Dec 94 |
| Pit 2 | Unknown | Yes | | Sloping RL 110 – RL 100, 105 to 110 mAHD | |
| Site 3 | Unknown | < 1m compacted clay | | 105 to 110 mAHD | Yes |
| Pit 4 | 30 m thick Cl/OB | Yes | | 105 to 110 mAHD | |
| Site 5 | Compacted Cl/OB | Yes | | 100 – 110 mAHD | |
| Pit 6 | | 90% (access open) | 2.7 m | 100 – 115 mAHD | 90% |
| Pit 7 | | In use | | | In use |
| Pit 7 Ext #1 | | In use | In use | In use | In use |
| Pit 7 Ext #2 | | In use | In use | In use | In use |

Cl: clay, OB: overburden

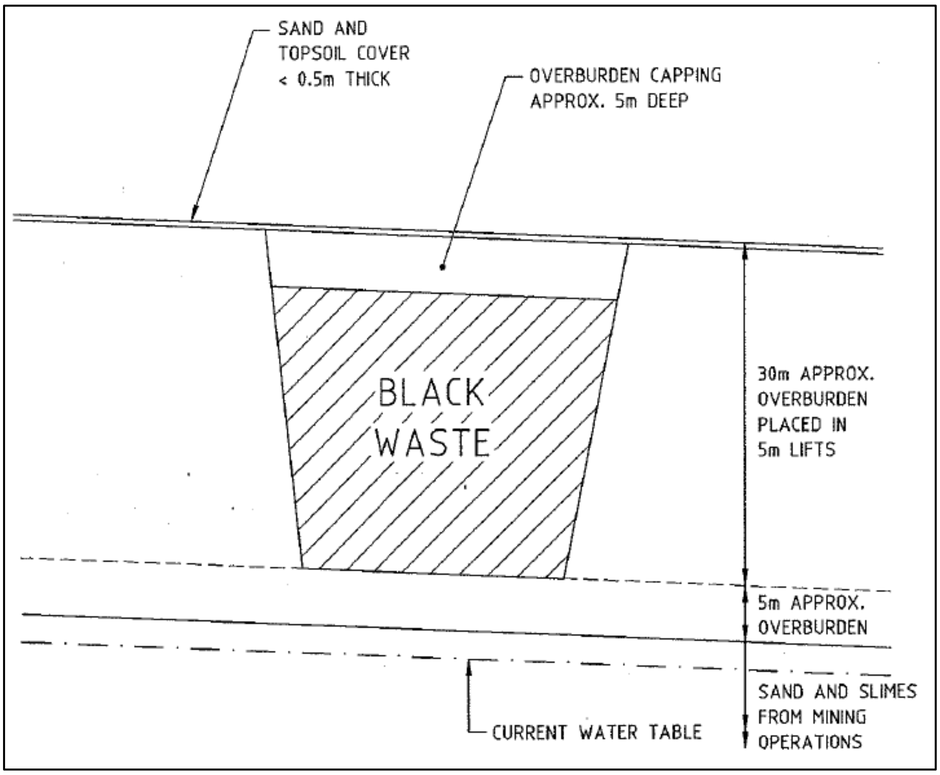


***Figure 5: Typical arrangement of earlier waste pits (HGM, 1996).***

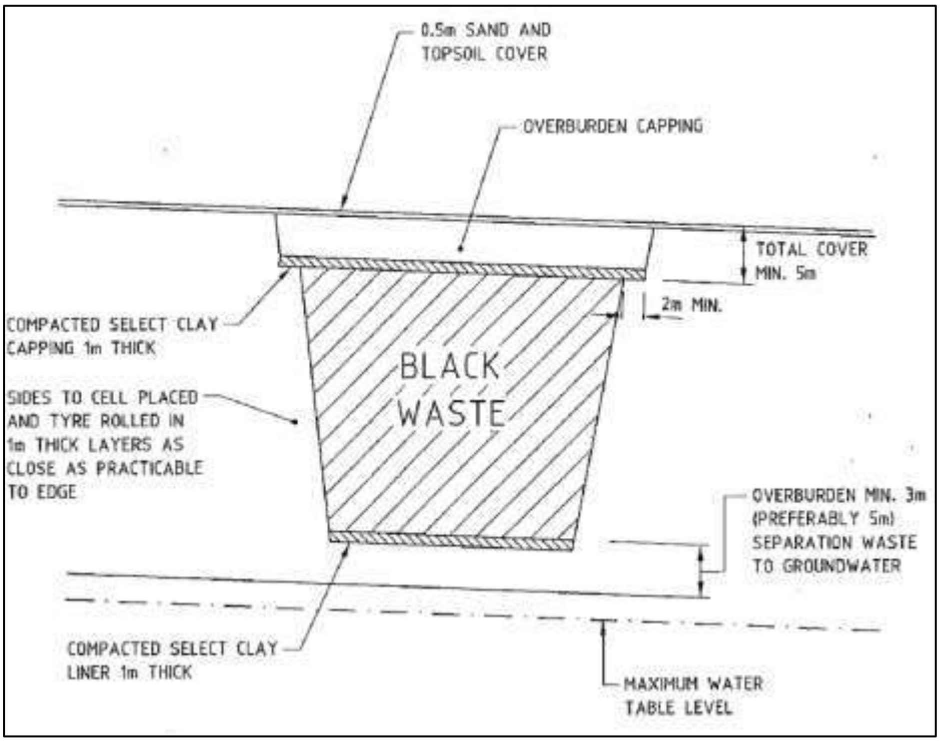


***Figure 6: Pit construction details for waste pits 7 and onwards (HGM, 1996).***

## Nature of the waste materials

The waste streams and residues disposed at the MRF include:

- Iron oxide residue;
- Neutralised Acid Effluent residue;
- Non-magnetic fines and cooler lumps (sinter);
- Kiln scrubber liquor and solids;
- Char; and
- $TiO_2$ solid residue (Kwinana).

Various other mining by-products are transported to Cooljarloo from Chandala and Kwinana for disposal, including:

- White tailings and screen 1 and 2 oversize (waste sand);
- Pre-screen tailings (clay and oversize waste sand);
- Coarse rejects (coarse sand containing up to 0.5% monazite, a naturally occurring radioactive material, NORM).

Kiln waste and Non-magnetic fines

The production of synthetic rutile at Chandala involves heating ilmenite, coal and char in a kiln under reducing conditions, whereby the resulting carbon monoxide gas reduces the iron oxides in the ilmenite to metallic iron. The reduced ilmenite is then graded and magnetically separated from partially burnt coal (in the form of char) and some of the other mineral impurities which are non-magnetic; the iron product is then oxidised in the presence of ammonium chloride (as a catalyst) and separated from the synthetic rutile grains, which are then polished by immersion in sulfuric acid before being dried.

Char, ash, non-magnetic fines and other agglomerates created in the kiln due to the pyrolytic process are separated from the reduced ilmenite using screens and magnetic separators. The non-magnetic fines are considered a waste.

The waste gas produced by the pyrolytic process is conditioned by wetting particulates with a saline process liquor spray, generating a liquid effluent and residue solids. As it carries dissolved sulfur dioxide and hydrogen sulfide, produced in the reduction kiln, the liquid effluent is acidic and is separated from the solids to be used in other processes. It contains a high zinc content and moderate manganese levels.

Due to the complex nature of reactions in the reduction kiln, the mineralogy of solid waste residue produced is subsequently complex. Calcite, haematite and magnetite may occur, along with, assuming water is a solvent, amorphous metal sulfides and insoluble metal-organic complexes. Leachates of kiln waste are therefore likely to contain low concentrations of heavy metals and trace elements, and significant concentrations of lead and zinc are likely to be mobilised under moderately acidic conditions.

Leachates developed from scrubber solids are likely to have a neutral pH and an initial salinity of 200 – 500 mg/L TDS, characterised by low lead and zinc concentrations. However, in the presence of sulfide minerals, a strongly acidic and saline leachate could develop via sulfide oxidation, with the main groundwater contaminants of concern being lead and zinc.

The non-magnetic fines stream is separated from other kiln waste streams due to the low-sulfide nature of the material and trucked back to the Premises as backfill. It generally contains high concentrations of carbon, titanium, iron and aluminium due to the presence of unburnt charcoal, unreacted ilmenite, silicates and metal oxides.

Iron oxide residue

Iron oxide residue is formed during the aeration process of synthetic rutile production and consists of ultra-fine particles (0.2 µm and 10 µm). It is separated in a cyclone circuit following aeration and transported by pipeline to an oxide dam as an ammonium chloride slurry, where the oxide solids are allowed to settle. The ammonium chloride supernatant liquor is decanted and recirculated back to the process for reuse, while the dried residue is periodically excavated from the dams and transported to Cooljarloo for disposal.

Solubility tests indicate extractable levels of heavy metals from dry iron oxide residues are generally low. Manganese is the only heavy metal with a high extractable concentration, indicating that heavy metals in the iron oxide residue are present in a strongly-bound metallic form, whilst weakly-bound manganese was mobilised under moderately acidic conditions.

Leachates developed from the iron oxide residues are likely to be mildly acidic and have an initial salinity of several thousand mg/L TDS, due to remnant ammonium chloride liquor. The presence of iron oxides below the water table may increase heavy metal concentrations, due to reductive mobilisation, with the main groundwater contaminants of concern being:

- salinity;
- inorganic nitrogen; and
- manganese.

Neutralised Acid Effluent

A further process in the production of synthetic rutile at Chandala involves the use of sulfuric acid to leach impurities from the synthetic rutile. The acid effluent from this process (pH 2) is subsequently neutralised with slaked lime to form neutralised acid effluent (NAE) (pH 8), which is primarily gypsum.

The solids are separated from the liquid at the Chandala waste management plant, through a series of thickeners and settling ponds, with the final filter-pressed solids transported to the Premises for disposal.

The dominant mineral components of NAE leachate residue are likely to have a pH range of 7 to 8 and a salinity range of 2,000 – 3,000 mg/L due to calcium sulfate dissolution. NAE residue below the water table may increase the concentration of heavy metals in leachate; the rate of dissolution is expected to be low due to the presence of calcite. The main contaminants of concern to groundwater from NAE residue are:

- sulfate;
- soluble ferrous iron; and
- divalent manganese.

**For noting:**

DWER's experience in relation to historical disposal of NAE filter cake in a poorly lined facility at the former-South Capel mine site has demonstrated that this residue has the potential to release significant concentrations of sulfate, iron and manganese to groundwater.

Other residues

Several other minor waste streams created during the synthetic rutile process are commonly co-disposed of, in numerous combinations, with the residues outlined above. These include:

- contaminated char;
- hydrocarbon spillages;
- other wastes, such as pond lining, materials from clean ups and decommissioning infrastructure at the Kwinana plant.

### Chemical testing

Analyses for metals, pH and sulfur content was first undertaken in the mid-1990s as part of initial investigations (HGM, 1996) into the long term environmental risks associated with black waste disposal. The results indicated that filter cake samples contained elevated levels of arsenic, chromium and lead concentrations in relation to typical background soil concentration ranges (ANZECC, 1992), and there was potential for salinity to be generated and heavy metals to be mobilised in black waste leachate. Subsequent leachate testing indicated that chromium from the filter cake samples was the only heavy metal of consequence.

The Part V licence has required ongoing chemical testing of black waste since 2003, in order to demonstrate that the leachable concentrations of contaminants do not exceed Class III landfill criterion[1]. Analyses are required to be conducted at least biannually (6-monthly). Average

[1] This is based on the assumption the recent waste pits are constructed to a standard equivalent to a Class III landfill, i.e. lined with leachate collection (DEC, 2009).

concentrations for heavy metals over the past 4 annual periods are summarised in Table 5.

The results indicate that average concentrations of several heavy metals are well in excess of the ecological investigation levels (EILs) listed in the *Australian and New Zealand Guidelines for the Assessment and Management of Contaminated Sites* (ANZECC/NHMRC, 1992), particularly chromium and nickel in filter cake samples from Kwinana. Other notable concentrations (average) include arsenic, zinc, lead and manganese in filter cake samples from Chandala; however similar to the findings from HGM (1996), subsequent leachate testing has indicated that chromium from the filter cake samples is the only heavy metal of consequence (Table 6).

**Key findings:**

1. Co-disposal of coal waste in the MRF poses a risk of leaching a range of other metals and metalloids, including mercury, cadmium and lead, as noted in the leaching tests conducted by HGM (1996).
2. Due to the presence of elemental carbon (in coal char), reducing redox conditions in the black waste pits would be expected initially, but repeated wetting and drying cycles under the influence of seasonal infiltration events and/or varying groundwater levels could lead to a lowering of the sorption capacity of some mineral phases within the black waste and the consequent release of metals into solution, thereby increasing the potential for leaching over time.

## Waste management strategy

According to HGM (1996), the management strategy for mineral processing residues is based on burial and long-term containment, where the generally low permeability of the overburden materials limits the ingress of moisture to the materials and the movement of any collected leachate to groundwater.

The Cooljarloo Environmental Management Programme (EMP), prepared to meet the intent of the mine lease conditions issued under the State Agreement and conditions within MS 37, includes a commitment to "ensure that no leachate from past, present or future containment sites can contaminate groundwater". This was amended from the previous performance standard in 2001, which required that no leachate is to be generated or detectable from the MRF pits, as this was shown to be impractical.

Background (pre-mining) groundwater quality in the 'south' mine area is generally of good quality, with low levels of dissolved metals and salinity. The use of groundwater for potable purposes is currently undetermined, but may be a possibility at the conclusion of mining. Groundwater, wetlands and water dependent ecosystems have been identified as the most sensitive ecological receptors, particularly Mullering Brook and its associated wetlands to the west of the MRF (PPK, 2001b).

The study conducted by HGM (1996) identified the potential for leachate generation from black waste. The main conclusions from this study were:

- there is some potential for heavy metals to be mobilised in leachate; however the risk is low given the generally alkaline environment expected to exist within the waste pits and the potential for heavy metals to adsorb onto clay particles in the underlying soils;
- there is some potential for salinity to be generated in leachate, which can only be controlled by limiting moisture ingress to the waste pits and limiting moisture flows from the base of the pits; however the generation of a salinity plume should be easy to detect via monitoring bores (natural groundwater is relatively fresh compared to the salinity of

**Table 5: Chemical analysis of mineral processing residues – average values 2014 – 2017**

| Waste type | Heavy metals (mg/kg) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | As | Be | Cd | Cu | Mn | Mo | Ni | Pb | Se | Zn | Cr (IV) | Ag | Hg | Th | U |
| Filter cake, Kwinana | 15.8 | 5.5 | 1.1 | | | 36.9 | 914 | 113 | 8.4 | | 265 | 3.5 | 0.06 | Na | Na |
| Pugged waste with IO/NAE, Chandala | 34.7 | 1.7 | 0.6 | 2.4 | 259 | 1.7 | 21.1 | 936 | 3.4 | 293 | 1.0 | Na | 0.1 | 21.4 | 3.2 |
| SRE filter cake, Chandala | 418 | 2.0 | 1.7 | 3.8 | 351 | 4.8 | 15.2 | 2846 | 19.9 | 1500 | 1.0 | Na | 0.1 | 12.3 | 2.9 |
| IO/NAE filter cake, Chandala | 30.4 | 2.0 | 1.8 | 2.2 | 1147 | 14.4 | 17.3 | 36.9 | 10.5 | 10.9 | 1.0 | Na | 0.3 | 6.8 | 1.7 |
| Pugged waste with SRE, Chandala | 85.4 | 1.6 | 0.6 | 2.6 | 233 | 3.0 | 15.1 | 2109 | 3.9 | 563.8 | 1.0 | Na | 0.1 | 20.6 | 2.0 |
| White tails, Chandala | 1.8 | 0.9 | 0.4 | 0.8 | 0.9 | 0.9 | 0.9 | 3.3 | 2.1 | 1.0 | 0.9 | Na | 0.1 | 2.9 | 1.1 |
| Spiral tails, Chandala | 1.7 | 0.8 | 0.3 | 7.0 | 8.0 | 0.8 | 0.9 | 62.6 | 1.7 | 4.5 | 0.8 | Na | 0.1 | 30.4 | 4.3 |
| Coarse rejects, Chandala | 19.8 | 0.8 | 0.3 | 1.3 | 15.6 | 0.8 | 0.8 | 87.2 | 1.6 | 11.2 | 0.8 | Na | 0.1 | 215 | 13.2 |
| Environmental Investigation Levels (ANZECC/NHMRC, 1992) | 20 | - | 3.0 | 100 | 500 | 40 | 60 | 600 | - | 200 | 1.0 | - | 1.0 | - | - |

Note: shaded results are those exceeding the EIL.

**Table 6: Leaching results of black waste constituents – average values 2014 – 2017**

| Waste type | Dissolved heavy metals (mg/L) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | As | Be | Cd | Cu | Mn | Mo | Ni | Pb | Se | Zn | Cr (IV) | Ag | Hg | Th | U |
| Filter cake, Kwinana | *<0.05* | *<0.01* | *<0.01* | <0.01 | 0.45 | 0.23 | <0.02 | *<0.03* | 0.11 | <0.02 | 0.57 | *<0.01* | <0.00005 | Na | Na |
| Pugged waste with IO/NAE, Chandala | *<0.05* | *<0.01* | *<0.01* | <0.01 | 0.03 | <0.03 | <0.02 | *<0.03* | *<0.1* | <0.02 | 0.005 | Na | <0.00005 | 0.0015 | 0.00066 |
| SRE filter cake, Chandala | 0.08 | *<0.01* | *<0.01* | <0.01 | 0.19 | 0.05 | <0.02 | 0.05 | 0.14 | <0.02 | 0.005 | Na | <0.00005 | 0.0013 | 0.00051 |
| IO/NAE filter cake, Chandala | *<0.05* | *<0.01* | *<0.01* | <0.01 | 4.16 | <0.03 | <0.02 | *<0.03* | *<0.1* | <0.02 | 0.005 | Na | <0.00005 | 0.0012 | 0.00050 |
| Pugged waste with SRE, Chandala | *<0.05* | *<0.01* | *<0.01* | <0.01 | 0.03 | <0.03 | <0.02 | *<0.03* | *<0.1* | <0.02 | 0.005 | Na | <0.00005 | 0.0013 | 0.00173 |
| White tails, Chandala | *<0.05* | *<0.01* | *<0.01* | <0.01 | <0.02 | <0.03 | <0.02 | *<0.03* | *<0.1* | <0.02 | 0.005 | Na | <0.00005 | 0.0041 | 0.00080 |
| Spiral tails, Chandala | *<0.05* | *<0.01* | *<0.01* | <0.01 | <0.02 | <0.03 | <0.02 | 0.04 | *<0.1* | <0.02 | 0.005 | Na | <0.00005 | 0.0016 | 0.00170 |
| Coarse rejects, Chandala | *<0.05* | *<0.01* | *<0.01* | <0.01 | <0.02 | <0.03 | <0.02 | 0.06 | *<0.1* | <0.02 | 0.005 | Na | <0.00005 | 0.0314 | 0.00240 |
| Drinking water health value (NHMRC, 2011) | 0.01 | 0.06 | 0.002 | 2 | 0.5 | 0.05 | 0.02 | 0.01 | 0.01 | 3 | 0.05 | 0.1 | 0.001 | - | 0.017 |

Note: shaded results are those exceeding the guideline. Italicised results are those tested to a LOR exceeding the specified guideline value.

black waste leachate); and

- future waste pits should be formally designed and constructed in a manner and using materials that minimise the potential for leachate generation, including a minimum separation to groundwater, lining of pit floors and capping following pit closure.

**Key findings:**

1. The assessment by HGM (1996) appears to have overlooked the fact that some metals and metalloids form stable oxyanions in solution and are mostly soluble under alkaline rather than acidic conditions, e.g. chromate, molybdates, arsenate, etc.
2. Sulfate is likely to be a large component of any saline groundwater plume. Elevated concentrations of this anion discharging to wetlands can trigger phosphorus release from sediments and the phenomenon known as 'internal eutrophication', which can lead to hydrogen sulfide toxicity of wetland plants.

During construction of the sixth waste pit, it became evident that the in-situ soils were unlikely to achieve permeabilities as low as $10^{-9}$ m/sec or lower by compaction or blending alone. Golder Associates (2000) concluded the lowest practicable permeability for a liner using locally sourced material was $10^{-7}$ m/sec, and that installation of such a liner would not significantly reduce the migration of contaminants to groundwater, providing the in-situ soils at the base of the pits have a permeability of at least $10^{-5}$ m/sec.

A subsequent risk analysis regarding current and future receptors associated with the site (PPK, 2001b) found that increases in groundwater salinity presented the biggest long-term management issue, particularly with respect to future human users of groundwater resources in the vicinity of the site, both for potable water supply and for other beneficial uses such as irrigation. A number of recommendations were made regarding changes to the capping design of existing waste pits, and lining requirements of proposed waste pits, some of which were included in amendments to the EMP in 2001 and have since been implemented by the licence holder for waste pit 6 and onwards. In practice, this involves:

- separation of at least 5 metres between the water table and black waste, using placed and compacted overburden;
- a 1 metre thick, clay lining placed and compacted in the base of each cell to achieve the lowest possible permeability with the clay materials present on-site;
- placement and compaction of the pit walls in 1 metre thick layers tyre rolled in close proximity to the edge;
- the use of at least 5 metres of clay overburden over the pits with a 0.5 metre deep, sandy, free draining surface layer; and
- the placement and compaction of a 1 metre minimum thick clay capping to each pit, the top surface of the clay cap being configured to provide minimum drainage slopes of 3-5% and to avoid any ponding.

**Key findings:**

1. Based on the information available, the risks associated with the leaching of metals and metalloids from the mineral processing residues appear to have been poorly assessed.
2. In order to properly assess the risks posed by historical disposal in unlined or partially-lined pits at the site, testing under the Leaching Environmental Assessment Framework (LEAF) published by the USEPA (or the equivalent European Union suite of leaching tests) is required.
3. LEAF test procedures are considered to be the current best practice methodologies for assessing the leaching potential of waste-derived materials, and they have the advantage of characterising the leaching potential of waste materials under a range of pH and redox conditions.
4. A full assessment of leaching potential under the LEAF would also be dependent on the development of a comprehensive conceptual site model for the MRF, which would need to

include a detailed description of the hydrogeological setting for the site.

5. Increasing the groundwater separation distance will have no impact on reducing saline groundwater contamination – it simply means that any contamination will take longer to reach the water table.

### Surface water management

A bund constructed of overburden is located along the downslope edge of Waste Pit 7 to contain surface water runoff and seepage from the MRF and to prevent runoff into Mullering Brook. The bund is approximately 100 m from Mullering Brook, is approximately 1 km long and sits above the compacted clay floor (refer to section 8.8).

An overflow drain is positioned 1 m above the floor at the lowest point of the bund, to allow water to overflow externally from the MRF, should the holding capacity of this area reach capacity.

### Groundwater monitoring network

The licence holder has installed a series of waste monitoring bores that are monitored on a quarterly basis for water level and chemistry. A total of eleven bores are currently monitored and are identified within the Groundwater Operating Strategy with the prefix 'WMB'. The locations of the WMB series bores in relation to the black waste pits are illustrated in Figure 4.

The monitoring data from the WMB series bores are reviewed on an annual basis with the aim of identifying impacts on groundwater quality (refer to section 7.2).

### Classification

In previous Part V licences issued for the Premises, the MRF has been referred to as a landfill, with specific reference to *Category 64: Class II or III putrescible landfill*. This is most likely due to the waste material being generated and delivered to the Premises from an off-site process and from another site.

In view of the State Agreement, which establishes that operation of the integrated project is a closed circuit, i.e. process wastes from Chandala and Kwinana are returned to the Premises for discrete disposal, disposal of mineral processing residues at the Premises is essentially a component of mineral sands processing for the purposes of the EP Regulations.

Reference to Category 64 has not been included in the revised licence and the environmental risk associated with the disposal of mineral processing residues from Chandala and Kwinana has therefore been included within the scope of Category 8.

Advice from the Department of Mines, Industry Regulation and Saftey (DMIRS) indicates that although the MRF is not a traditional tailings storage facility (TSF), it is more a mix of a TSF and a waste dump, i.e. a dry stack TSF. These such facilities have different risks to a standard slurry TSF, and 'dry' stacking as a tailings deposition method is still required to comply with the DMIRS *Code of Practice and guidelines for tailings storage facilities* (DMP, September 2013).

**Key findings:**

The Delegated Officer has determined:

1. the disposal of mineral processing residues from Chandala and Kwinana is a component of mineral sands processing;
2. the Mineral Residue Facility is a 'dry stack' tailings storage facility and not a landfill; and
3. the risk assessment of the MRF is based on the known nature and characteristics of the residues, in addition to the actual amount and specified management. The disposal of other, unspecified wastes may alter the assessed risk.

As a consequence the delegated officer has removed reference to Category 64 and clarified the provision of disposing wastes other than mineral processing residues in the revised licence.

### 4.1.7 MRF Extension – Cell 8 application

The licence holder proposes to construct an additional, eighth waste cell (Cell 8) at the MRF, as the current active cell, Cell 7, is expected to reach capacity in December 2019. A licence amendment application to allow construction and operation of the new cell was submitted by the licence holder in November 2018.

DWER referred the application to DMIRS, prior to validation of the application in November 2019. DMIRS advised the licence holder should demonstrate the proposed cell complies with the DMIRS TSF Code of Practice, and that further technical information should be provided to support this.

Table 7 lists the documents submitted for assessment, with full references provided in Appendix 1.

**Table 7: Documents and information submitted with Cell 8 extension application**

| Document/information description | Author | Date/version |
|---|---|---|
| Attachment 3A:- Mineral Residue Facility Cell 8 | Tronox | 28/6/2018 |
| Mineral Residue Facility – Geotechnical Report, including:<br>• Attachment 1: Hydrological study;<br>• Attachment 2: Geotechnical study. | Talis Consultants | October 2019 |

The proposed Cell 8 will be located adjacent to the northern side of the existing Cell 7 Extension 2 facility and covers an area of 36 ha (refer to Figure 4). The design capacity is for around 3.6 million cubic metres of mineral processing residues, and will provide for an estimated 20 year lifespan.

The cell lining has been designed in accordance with the *Water Quality Protection Guideline No.3 – Mining and mineral processing – Liners for waste containment* (Water and Rivers Commission, 2000).

#### Engineering design

Overview:

- Floor lining will be stitched with the existing Pit 7 Extension 1 & 2 floor lining;
- Floor will be graded towards the lowest point in the northwest corner, where an overflow drain will be located in the wall 1.0 m above the floor, to allow any pooled water to drain into an adjacent dam (Figure 7). The licence holder expects most of the water collecting at this low point will evaporate and the drain will not be used;
- Minimum separation to the highest known groundwater table of 3 m;
- The MRF will be projected at a 1:14 maximum slope angle in north and westerly directions and 30 degrees at the eastern side where the MRF will later be extended.

Floor design:

- Floor will be designed to function as a clay liner to prevent seepage;
- Floor liner thickness:
  - Clay layer: 300 mm placed in two layers (150 mm each) compacted and rolled to achieve >95% of Maximum Dry Density in accordance with AS 1289;
  - Each compacted layer will be tested to confirm that densities have been achieved;
  - Class I or 2 overburden layer: 300 mm, compacted on the top of the clay lining to help avoid lining erosion.

Base liner minimum requirements:

- Clay (DDR of >95%) soil with a permeability < $10^{-9}$ m/s;
- Percentage fines passing a 75-micron sieve >25%;
- Liquid limit <70;

- Plasticity index >15; and
- Emerson class number 5 to 6

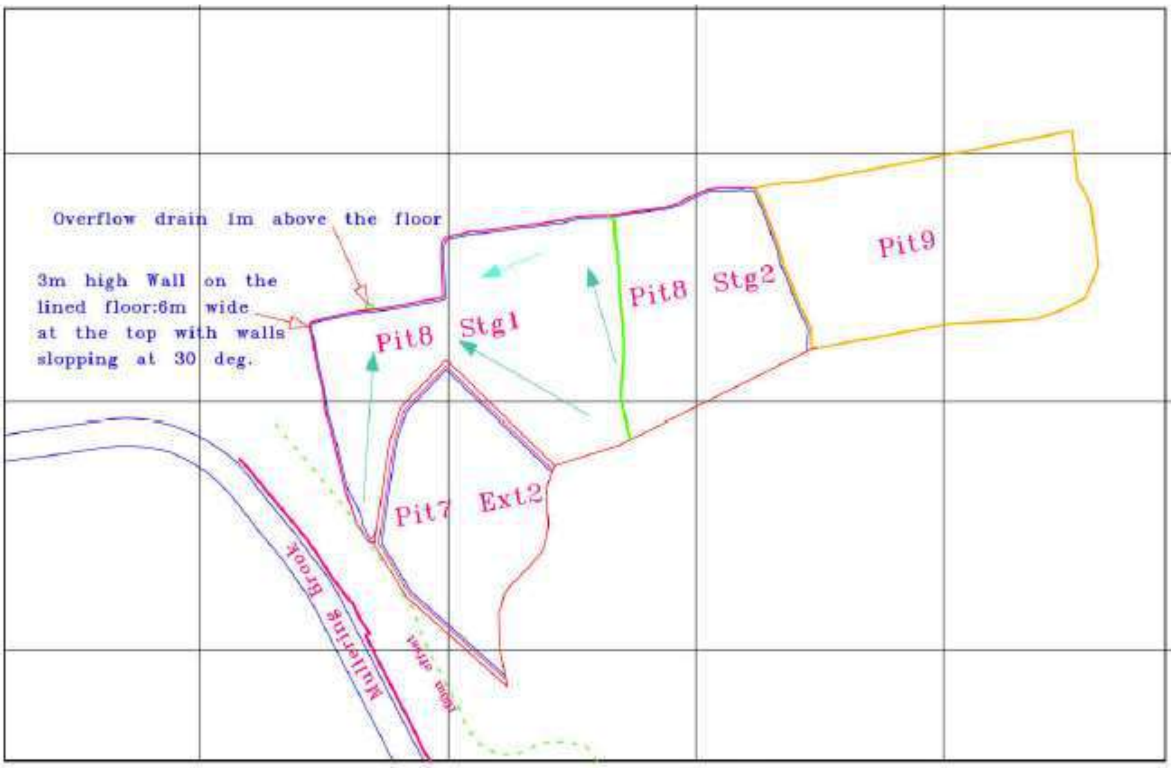


***Figure 7: Drain location in Cell 8***

<u>Cell 8 design:</u>

- Fill: 3,666,000 m$^3$;
- Capacity 21 years at 28,000 tonnes per month;
- Waste density: 2.0

Capping design – the final landform capping profile will be constructed by placing 300 mm compacted clay overburden, followed by 1 m of Class 1 and Class 2 overburden, 1 m of Class 1 and a final 300 mm topsoil (Figure 8).

| Depth m BGL | Material |
|---|---|
| 0.00 - 0.3 | Topsoil |
| 0.3 – 1.3 | Class 1 |
| 1.3 – 2.3 | Mixed zone (50% Sand Tails and 50% overburden) |
| 2.3 – 2.6 | Compacted Overburden |

| Thickness (mm) | Material |
|---|---|
| 300mm | Overburden (Class 1 or 2) |
| 300mm | Compacted Clay (DDR >95%) |
| | Graded Floor |

***Figure 8: Capping and liner system design for Cell 8***

## Hydrological study

The licence holder has conducted a hydrological study (Talis, 2019) to demonstrate:

- how the potential for flooding of Mullering Brook or surrounding landscape will be mitigated over the long term from PMP/PMF rainfall events; and
- how the containment embankment would prevent surface flow off/ through the facility into Mullering Brook on an operational level (1% AEP, 72 hour rainfall event).

The study involved an extensive analysis of the behaviour of Mullering Brook, which concluded at no stage do the extreme rainfall events of 1:100 and 1:2,000 AEP approach the perimeter embankments of the MRF or the proposed Cell 8. However, there are two sets of pipe culverts located on the diversion channel which would significantly constrain flood flow, which would result in the area surrounding these culverts to be inundated and the culverts themselves being overtopped to significant depths. In addition, these flows would encroach upon the approach embankments of the MRF and may cause erosion due to the flow velocities.

The study also indicated that a significant volume of runoff from the surface area of the MRF can be stored between the final face of the placed residue and the perimeter embankment, and this capacity will remain available until the surface of the MRF is rehabilitated. An emergency spillway will be constructed 0.3 m below the embankment crest, where excess flows would discharge towards mined out areas to the northwest of the MRF.

<u>DWER technical review:</u>

DWER's review of the *Mineral Residue Facility Hydrological Study* (Talis, 2019) provided as part of the application, identified that:

- the study was carried out in an appropriate manner and the calculations appear to be sound; and
- based on the information provided, the licence holder has demonstrated that in an operational rainfall event, breach of ponded water and release to the environment in the vicinity of the MRF is unlikely, based on the holding capacity for stormwater events.

## Seepage assessment

The licence holder has conducted a seepage assessment to determine the volume of seepage from the proposed cell towards groundwater (Talis, 2019). The assessment involved finite difference analysis using Seep/W and continuous flow calculation based on Darcy's equation for seepage through saturated soil material.

<u>Results:</u>

- Seep/W model indicates a flow rate of $1.873 \times 10^{-5}$ $m^3$ per day over a segment length of 237 m. A reduction of this rate of flow in terms of seconds gives a value of $2.168 \times 10^{-10}$ $m^3/s$ over the length of the base;
- calculation of seepage using Darcy's equation indicates a flow per unit area in the order of $3.25 \times 10^{-8}$ $m^3/s/m^2$, which is more conservative than the finite element analysis;

Talis (2019) concludes that as the proposed design incorporates a 300 mm compacted clay lining of natural material, the criteria presented in the *Water Quality Protection Guidelines No. 3 – Mining and mineral processing – Liners for waste containment* (DMP, 2000) are generally met with the intention to minimise seepage.

<u>DWER technical review:</u>

DWER has consulted with DMIRS on the *Mineral Residue Facility Geotechnical Study* (Talis, 2019) provided as part of the application, and has identified that:

- the seepage assessment was carried out in an appropriate manner and the calculations appear to be sound; and

- based on the information provided, the potential for contaminants to enter the groundwater is reduced with the proposed lining system in place.

### Slope stability analysis

The licence holder has conducted a stability analysis (Talis, 2019). The stability analysis program SLIDE 8.016 from RocScience was used to undertake the limit equilibrium using the Bishop simplified circular analysis for the residue face, to establish the adequacy of the design of the proposed Cell 8.

Results:

**Table 8: Summary of stability analysis for residue face**

| Scenario | Method | Factor of Safety[1] | Comments |
|---|---|---|---|
| Residue face at full height | Drained circular | 4.54 | 1V:14H slope |
| Residue face at full height with seismic loading (OBE – 1.475 AEP) | Drained circular | 3.49 | 1V:14H slope |
| Residue face at full height with seismic loading (SEE – 1.1000 AEP) | Drained circular | 2.82 | 1V:14H slope |
| Residue face at full height with seismic loading (1:2500 AEP) | Drained circular | 2.20 | 1V:14H slope |

Note 1: *ANCOLD guidelines recommend a minimum FoS for embankments of 1.0 – 1.2 for pseudo-static loading conditions.*

Talis (2019) comments on the MRF not being designed as a tailings storage facility due to the low moisture content of the residue, which is mechanically placed and compacted within the facility that is intended to avoid the accumulation of water. As the structure is not water retaining, therefore the ANCOLD guidelines or the DMIRS TSF Code of Practice should not apply. However, the stability of the MRF has been assessed using ANCOLD guidelines and criteria, which are conservative in this situation, where the design satisfies the requirements and is therefore fit for purpose.

## 4.2 Infrastructure

The Cooljarloo mine infrastructure, as it relates to Category 8 activities, is detailed in Table 9 and with reference to the site plan (attached in the revised licence).

**Table 9: Cooljarloo mine infrastructure**

| **Infrastructure** | |
|---|---|
| **Prescribed Activity Category 8** | |
| ***Dredging operations*** | |
| 1 | Dredge pond |
| 2 | Suction-cutter dredges, Cooljarloo I (6,000 t/hr capacity) and Pelican (2,000 t/hr) |
| 3 | Floating wet concentration plant (4,200 t/hr capacity). Includes trommel, hydro-cyclones and gravity spiral circuits |
| 4 | Drainage channels |
| 5 | Bore water tanks |
| 6 | Lime dosing pumping station |
| ***Dry mining operations*** | |
| 1 | Dozer trap, bulldozers push material into an in-pit hopper to screen ore and remove oversize |
| 2 | Land-based wet concentration plant. Includes hydro-cyclones and gravity spiral circuits |

| | |
|---|---|
| 3 | Dewatering pumps |
| ***Combined mining infrastructure*** | |
| 1 | HMC stockpile(s) |
| 2 | Tailings dams |
| 3 | Solar evaporation ponds |
| 4 | Overburden dumps and topsoil stockpiles |
| 5 | Process water ponds |
| ***Directly related activities*** | |
| 1 | Mineral Residue Facility. Disposal location for downstream processing wastes returned to site |
| 2 | Thickener underflow, tailings and return water pipelines |

## 4.3 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 revised 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.

# 5. Legislative context

## 5.1 Part IV of the EP Act

### 5.1.1 Background

The original Cooljarloo mine proposal, which sought mining of the then-known areas of mineralisation within M268SA, was assessed by the EPA in 1987/88 as an EMRP. The proposal was approved through the issue of MS 37 and mining commenced at the site the following year.

In 1999, the EPA determined to formally assess a proposal to mine an extension area to the south, termed ore bodies '27 200' and '28 000', at the Public Environmental Review (PER) level of assessment. The proposal was approved through MS 557.

In 2008, the EPA determined to formally assess a proposal to mine an extension area in the north-west corner of M268SA, termed the 'Falcon Extension' (ore body 25 000 and the Lone Deposit), at the Environmental Protection Statement level of assessment. The proposal was approved through MS 790, with some conditions later amended through the issue of MS 977.

In 2013, the licence holder referred a proposal to mine an expansion located west of the South mine operations, termed 'Cooljarloo West'. The proposal is currently being assessed at the PER level of assessment, with the EPA currently preparing its report on the outcome of its assessment.

As part of the Cooljarloo West proposal, the licence holder has requested that all current statements be reviewed and amalgamated into a single statement. A summary of each statement and the key matters relating to Division 3, Part V of the EP Act is discussed below.

### 5.1.2 Ministerial Statement 37

Bulletin 330 (March 1988) provides the EPA's assessment of the original Cooljarloo mine proposal. The key environmental factors identified are generally related to the impacts of mining and the spread of dieback on flora and fauna of conservation significance and on proposed conservation areas, rehabilitation 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.

MS 37 strongly focuses on the environmental management commitments made by the proponent in the ERMP, with the majority of conditions and commitments related to rehabilitation (including realignment of Mullering Brook), dieback control, radiation hazards and groundwater drawdown.

**Key findings:**

The Delegated Officer notes that:

1. Although MS 37 remains active, many of the conditions are no longer relevant, as they have since been cleared by the EPA as being completed by the proponent;
2. There is no apparent regulatory duplication between the conditions of MS 37 issued under Part IV of the EP Act and the scope of the existing licence. However, MS 37 does require the proponent to conduct monitoring of the following themes:
    a) the health and abundance of native vegetation within proximity to mining areas;
    b) groundwater levels and quality as a result of drawdown; and
    c) rehabilitation performance;

    with results to be forwarded to the Environmental Protection Authority (the sole Government department responsible for administering the EP Act at the time).

    Consistent with section 59B of the EP Act:

    (7) *If the proposal amendment, revocation or suspension is related to a proposal which has been referred to the Authority under section 38, the CEO is not to so amend, revoke or suspend –*

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

    conditions have been set out in the revised licence for the targeted monitoring of groundwater quality in areas where tailings have been deposited and where mining has caused increasing salinity and acidity.
3. The Department of Biodiversity, Conservation and Attractions (DBCA) is the relevant authority with respect to rehabilitation performance of native vegetation following mining.

### 5.1.3 Ministerial Statement 557

Bulletin 990 (September 2000) provides the EPA's assessment of the proposal to mine the 27 200 & 28 000 orebodies. The key environmental factors identified include impacts on conservation values from clearing native vegetation, rehabilitation, and impacts on native vegetation and wetlands from dredge mining (as a result of groundwater drawdown). A number of recommendations were made, however none that were specific to emissions and discharges from the mining operation.

MS 557 contains a number of conditions that relate to minimising impacts on native vegetation values and wetlands during active mining, and post-mining rehabilitation performance.

MS 557 includes numerous references to former government departments (i.e. DEP, WRC) as being responsible for assessing compliance with specific conditions, procedures and commitments. In the present day, DBCA is the responsible authority with respect to all flora/dieback management conditions, and DWER for all groundwater management conditions and assessing compliance with the conditions, procedures and commitments of MS 557.

**Key findings:**

The Delegated Officer notes that:

1. Mining of the 27 200 & 28 000 orebodies was completed in 2004 and the disturbance area is currently under rehabilitation. Many of the conditions of MS 557 are therefore no longer relevant, as they have since been cleared by the EPA as being completed by the proponent;
2. There is no regulatory duplication between the conditions of MS 557 issued under Part IV of the EP Act and the scope of the existing licence. The remaining relevant conditions of MS 557 predominantly relate to rehabilitation of native vegetation and rehabilitation performance following mining.

### 5.1.4 Ministerial Statement 790 (including Statement 977)

Report 1299 (August 2008) provides the EPA's assessment of the proposal to mine the Falcon Extension. The key environmental factors identified include impacts to flora and vegetation, groundwater and rehabilitation and closure.

MS 790 contains a number of conditions that relate to minimising impacts on known declared Rare Flora, managing groundwater drawdown to prevent the disturbance of potential acid sulfate soils and impacts on the hydrology of the Mount Jetty creek system, and post-mining rehabilitation performance.

MS 977 was issued in 2014 to change implementation of condition 7 in reference to trigger levels for groundwater drawdown. The EPA considered the risk of oxidation of ASS from the effects of groundwater drawdown to be no longer present following the cessation of dewatering activities in 2012 and as such, condition 7-1 and Table 3 of Schedule 1 relating to trigger levels were removed.

MS 790 includes numerous references to the former-Department of Environment and Conservation as the advisory body and approval authority for all compliance reporting requirements. In the present day, DWER has assumed this role for all conditions relating to acid sulfate soils and groundwater drawdown conditions, and DBCA for all flora and vegetation and rehabilitation conditions.

**Key findings:**

The Delegated Officer notes that:

1. Mining of the Falcon extension was completed in 2012 and the disturbance area is currently under rehabilitation. Many of the conditions of MS 790 and MS 977 are therefore no longer relevant, as they have since been cleared by the EPA as being completed by the proponent;
2. There is no regulatory duplication between the conditions of MS 790 issued under Part IV of the EP Act and the scope of the existing licence. The remaining relevant conditions of MS 790 and MS 977 predominantly relate to rehabilitation of native vegetation and rehabilitation performance following mining.

### 5.1.5 Cooljarloo West

The licence holder referred the 'Cooljarloo West' proposal to the EPA in March 2013 under s.38 of the EP Act. The proposal is to expand the current mining operations to the west, by developing three new mine pits.

In June 2013, the EPA decided to assess the proposal and set a PER level of assessment with a four week public review period (EPA Assessment No. 1974), with the proponent to prepare the Environmental Scoping Document (ESD).

The EPA approved the ESD for the proposal in August 2013. The PER document was released for public review from 29 May 2017 to 26 June 2017, with a total of 9 submissions received. Issues raised on the proposal included:

- impacts on conservation significant flora, and vegetation communities arising from clearing, weeds and pathogens;
- impacts on habitat of Carnaby's cockatoo and potential for occurrence of Western Ground parrots;
- cumulative and indirect impacts;
- offsets; and
- rehabilitation.

The licence holder subsequently sought the EPA's consent for a change to the proposal under s.48A of the EP Act, relating to a minor reduction in the area to be cleared. The EPA consented to the change in December 2017.

The EPA is currently preparing its report on the outcome of its assessment of the proposal.

## 5.2 Contaminated sites

In 2007 the licence holder reported potentially contaminated sites at the Premises under the *Contaminated Sites Act 2003* (CS Act). Three parcels of land were reported based on historical site activities and site use as a mine including storage of mineral sand mine tailings, bioremediation of hydrocarbons, storage and disposal of fuels, chemicals and waste on-site.

In January 2013, the three parcels of land comprising Lot 3906 on Plan 170072 and two digitised parcels of land delineating areas around bioremediation facilities were classified by DWER as *possibly contaminated – investigation required* (DEC, 2013). A memorial (reference number M157340ML) was subsequently registered against the Certificate of Title for Lot 3906 (1980/17).

### 5.2.1 Possible contamination

Potentially contaminating activities that have been identified as associated with the site use as a mine include:

- Mineral sands mining (exposure of PASS);
- Light and heavy vehicle maintenance;
- Bulk fuel and oil storage;
- Dangerous goods storage;
- Mineral Residue Facility;
- Former bioremediation areas; and
- Clay fines dams, solar drying cells.

### 5.2.2 Site investigation work

Based on the site classification, the licence holder submitted a 'preliminary site investigation' (PSI) to DWER in 2017, which outlined a number of recommendations including conducting a groundwater review into the ASS related groundwater issues at the site, and further investigations into areas of potential environmental concern identified on the site. The licence holder then submitted to DWER in August 2018 a proposed strategy for a 'detailed site investigation' (DSI) based on these recommendations.

Upon review of the proposed DSI strategy, DWER noted that the characterisation of potential environmental risks posed by groundwater contamination at the site presents particularly complex technical challenges, and therefore formally requested the submission of a 'mandatory auditor's report' (MAR), to enable the site to be properly dealt with for the purposes of the CS Act.

## 5.3 Other relevant approvals

### 5.3.1 *Mineral Sands (Cooljarloo) Mining and Processing Agreement Act 1988*

The State Agreement was ratified in 1988 to promote development and employment opportunities within the region. It was made on behalf of the State with a joint venture between Yalgoo Minerals Pty Ltd[2] and KMCC Western Australia Pty Ltd[3] (the 'Joint Venturers') with respect to the mining of mineral sands and the construction and operation of a synthetic rutile plant and a titanium dioxide pigment plant.

The State Agreement defines the integrated regime for approval, management and monitoring of all stages of the project. The Department of Jobs, Tourism, Science and Innovation (JTSI) facilitates and administers the agreement on behalf of the Minister for State Development.

It is subject to approvals required under the EP Act. Environmental provisions under the agreement include requirements to prepare an Environmental Management Programme and to submit annual and triennial environmental reports to the Minister for State Development, outlining the mining and rehabilitation conducted and to detail planned future mining and rehabilitation activities.

JTSI refers the annual/triennial reports to relevant government agencies – the majority of which are members of the Mineral Sands Agreement Rehabilitation Coordinating Committee (MSARCC) – an advisory body that it chairs. MSARCC, of which DWER is a member agency, meets annually on-site to review and monitor the effectiveness of measures taken by the licence holder regarding the protection and management of the environment.

The licence holder has advised the State Agreement expires on 1 March 2020, at which point the operation will revert to standard mining lease under the *Mining Act 1978* (Mining Act).

### 5.3.2 *Rights in Water and Irrigation Act 1914*

By definition the mining operation is water intensive and there is total reliance on groundwater resources for all water requirements (PPK, 2001a). Both the Superficial and underlying Yarragadee Aquifers are exploited for their extensive groundwater resources under licences issued by DWER (Table 10).

**Table 10: Summary of current groundwater licences**

| Groundwater Well Licence No. | Groundwater area | Licensed aquifer | Licence type/ Purpose | Licensed allocation (kL/yr) |
|---|---|---|---|---|
| GWL104551 (10) | Gingin, Cataby confined | Perth Yarragadee North | Mineral ore processing and other mining purposes | 3,880,000 |
| GWL101017 (10) | Gingin, Wedge Island | Perth Superficial Swan | | 10,000,000 |
| GWL157540 (5) | Jurien, Nambung | Perth Yarragadee North | | 2,500,000 |
| GWL159548 (5) | Jurien, Nambung | Perth Superficial Swan | | 3,200,000 |

Due to the large volumes of high quality water being abstracted from the two aquifers spread across two different groundwater areas in a region where groundwater dependent ecosystems and other users are present, the groundwater licences require a detailed Groundwater Operating Strategy (GOS) to supplement licence conditions.

[2] *Yalgoo Minerals* was acquired by *Ticor Resources*, which was later acquired by South African miner *Exxaro Resources*. The mineral sands business of *Exxaro* was later acquired by *Tronox Ltd* in 2012.
[3] *KMCC Western Australia* was a subsidiary of the US-based *Kerr-McGee Chemical Corporation*. The chemical manufacturing division of *Kerr-McGee* was inherited by *Tronox Ltd* in 2005.

The GOS for the project describes the water use and abstraction regime, the water sources being accessed and relevant outcomes which need to be achieved to manage impacts on the environment and other users. It includes a series of commitments, clearly defining the responsibilities for managing and monitoring the impacts of taking the water, and reporting requirements.

### 5.3.3 *Mining Act 1978*

The Premises is one of two mineral sands operations that are principally governed by a State Agreement, and not the Mining Act.

DMIRS provides an advisory role to JTSI with respect to technical aspects of the mining operation and project proposals, and any issues identified by DMIRS are coordinated and led by JTSI.

DMIRS is required under existing practices to assess the annual and triennial environmental reports submitted under the Agreement to JTSI. In certain circumstances, DMIRS can issue directions or require further action be taken in relation to mining activities having an adverse impact on the environment and compliance with tenement conditions of ML268SA.

**Key noting:**

1. The licence holder has submitted a mining proposal under the Mining Act, in preparation for when the operation will convert to mining tenure upon expiry of the State Agreement on 1 March 2020.

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 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.

### 5.3.4 Radiological Council of WA

Deposits of mineral sands contain levels of naturally occurring radioactive material (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.

### 5.3.5 Federal Legislation

#### *Environment Protection and Biodiversity Conservation Act 1999 (Cth)*

The original Cooljarloo mine proposal was referred to the then-Department of the Arts, Sport, the Environment, Tourism and Territories (DASETT) under the *Environment Protection (Impact of Proposals) Act 1974* (EPIP Act). DASETT determined that assessment of the proposal by the EPA as an ERMP under the bilateral agreement would satisfy its requirements.

The EPIP Act was later repealed and replaced by the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), in order to avoid Commonwealth involvement in matters of ‘local or State significance’, and to confine its role to matters of ‘national environmental significance’.

The licence holder referred for consideration under the EPBC Act the proposals to mine the 27 200 & 28 000 orebodies and the Falcon Extension.

The 27 200 & 28 000 proposal was referred on the basis that two listed threatened species, Slender Andersonia *Andersonia gracilis* (flora) and Carnaby’s Black Cockatoo *Calyptohyncus latirostris* (fauna), may be affected by implementation of the proposal. The referral decision (EPBC 2000/23) was that the proposed action was not a controlled action.

The Falcon Extension proposal was referred on the basis that five listed threatened species and five listed migratory species may be affected by implementation of the proposal. The referral decision (EPBC 2007/3556) was that the proposed action was not a controlled action.

In September 2016, the Department of the Environment and Energy listed the *Banksia Woodlands* ecological community as endangered under the EPBC Act. This listing may impact on future developments at the Premises that require the clearing of this vegetation association.

## 5.4 Part V of the EP Act

### 5.4.1 Applicable regulations, standards and guidelines

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

DWER Guidance Statements which inform this assessment are listed in Appendix 1.

### 5.4.2 Works approval and licence history

The existing licence issued for the Premises (September 2012) has not been subjected to a detailed environmental risk assessment and is therefore inconsistent with DWER’s regulatory framework.

**Table 11: Works approval and licence history**

| Instrument | Issued | Nature and extent of works approval, licence or amendment |
|---|---|---|
| L5319/5 | 19/09/2001 | Licence reissue – issued to Tiwest Pty Ltd |
| L5319/5 | 16/07/2002 | Licence amendment – inclusion of conditions related to the construction of solar drying ponds to negate the need for further works approvals |
| L5319/6 | 29/09/2002 | Licence reissue – global changes only |
| L5319/7 | 30/09/2003 | Licence reissue – inclusion of conditions related to analysis of black waste |
| L5319/8 | 29/09/2004 | Licence reissue – issued for 2 years |
| L5319/8 | 22/09/2005 | Licence amendment following the Welker Review[4]. Changes to annual reporting conditions, notification requirements, dust conditions, MRF requirements |
| L5319/9 | 07/09/2006 | Licence reissue – global changes only |
| L5319/1989/10 | 21/08/2008 | Licence reissue – global changes only |
| L5319/1989/10 | 29/10/2009 | Licence amendment to permit disposal of inert wastes at the MRF |
| L5319/1989/11 | 24/09/2010 | Licence reissue – global changes only |
| L5319/1989/12 | 27/09/2012 | Licence reissue. Occupier changed to Tronox Management Pty Ltd |
| W5326/2012/1 | 21/03/2013 | Works approval for Pit 7 extension #2 at the MRF |
| L5319/1989/12 | 29/04/2016 | Licence expiry extended to 2027 via administrative notice |

[4] Welker Environmental Consultancy (2003). *Western Australian Licence Conditions: Independent Strategic Review*

| | | |
|---|---|---|
| L5319/1989/12 | 23/12/2019 | Licence review and approval for construction of MRF extension (Cell 8) |

### 5.4.3 Compliance inspections and compliance history

**Compliance inspections**

A compliance inspection was conducted on 3 March 2016. The licence holder was found to be compliant with the relevant licence conditions at the time (refer to section 5.4.2).

**Compliance Reports and Annual Environmental Reports**

A requirement of the existing licence is the submission of a compliance report by 1 April each year. The licence holder has declared full compliance with conditions of the existing licence (refer to section 5.4.2).

**Recent incidents and s72 notifications**

A number of incidents involving the dredge pond have occurred over the past few years:

- December 2016 – a hydraulic hose fitting uncoupled on the Pelican dredge, resulting in approx. 1,000 litres of hydraulic oil discharging into the dredge pond;
- March 2016 – failure of a dredge gearbox seal resulted in approx. 1,500 litres of hydraulic oil discharging into the dredge pond;
- A slow oil leak from the Cooljarloo I dredge gearbox into the dredge pond was identified in 2012. The volume of oil lost was estimated at 400 litres/month over the period 2012 – August 2014;
- In early 2014, the pH of the dredge pond dropped below pH 4.0, and by mid-2014 had dropped to pH ~3.2. The licence holder commenced an intensive lime dosing operation, in which the pond recovered to above pH 5.0 by the end of 2015. The lime dosing operation has continued and is required to maintain levels above pH 5.0.

### 5.4.4 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 s. 40 as part of a proposal referred under s. 38 does not require a clearing permit, providing the clearing is done in accordance with the implementation agreement or decision.

The EPA has assessed the ongoing clearing of native vegetation to facilitate mining on the Premises. This aspect is regulated through the relevant Ministerial Statements and is conditional upon the re-establishment of a fully functional ecosystem similar to the pre-disturbance landscape of all disturbed areas.

# 6. Location and siting

## 6.1 Siting context

The Premises is located in the State's coastal Wheatbelt region, around 175 km north of Perth and 30 km west of Dandaragan.

The mine is located immediately west of the Gingin Scarp, which is the prominent landform feature of the area. The southern portion of the mine boundary abuts the Brand Highway, the main highway linking the northern outskirts of Perth to Geraldton.

The majority of the mining lease area is within undisturbed UCL, with the remainder being freehold land cleared in the early 1970s. A large proportion of the area surrounding the mine comprises uncleared Crown Land that has been vested in conservation estate. The remaining land is alienated, most of which has been cleared for grazing and cropping activities.

## 6.2 Residential and sensitive premises

The nearest sensitive receptor is the Billinue Aboriginal Community (BAC), located on the south-eastern corner of Mullering Farm (Lot 100 on Diagram 82665). Lot 100 was ceded to the BAC by the licence holder in 1994.

The distances to residential and sensitive receptors are detailed in Table 12. It is noted these receptors are located closer to the Iluka Resources' Cataby Mineral Sands Project, which commenced operations in early 2019.

**Table 12: Receptors and distance from activity boundary**

| Sensitive land uses | Distance from prescribed activity |
|---|---|
| Billinue Aboriginal Community (population ~43) | SE corner of Mullering Farm. The BAC supplies the licence holder with native seeds for propagation and rehabilitation purposes |
| Brand Highway | Runs adjacent to the SE boundary of the Premises |
| Residential premises (farm house) | Approx. 4.2 km SE of the Premises boundary |
| Cataby roadhouse (motel)<br>Residential premises (farm house) | Approx. 6.4 km SE of the Premises boundary |

## 6.3 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. It consists predominantly of low dune ridges with interdunal swales subject to seasonal waterlogging.

The landscape mostly slopes westwards and is drained by westerly-flowing watercourses. The general features are typical of the Bassendean Sand complex which covers most of the Swan Coastal Plain.

As a result of mining operations, the site has been extensively cut and filled. However as a result of progressive rehabilitation activities, the topography of the area has been mostly returned to the original gently sloping plain terrain.

### 6.3.1 Geology

The mineral sands deposits on the Premises occur within a series of unconsolidated sedimentary deposits of relatively recent (Quaternary 1 – 2 million years) age. They generally originate from the adjacent Yilgarn Block (ancient granites of Archaean origin), which has been eroded, transported by rivers and streams and deposited as beach sands along former coastlines. Sea levels have dropped and the coastline retreated, leaving linear heavy mineral deposits well inland of the present-day coastline.

The deposits are located in a series of ancient beach strandlines known collectively as the Gingin shorelines[5]. The mineralised strands are 40 to 90 metres above present sea level, with a gentle dip to the south.

The deposits are classified into three categories according to their physical position and nature of mineralisation. Upper level deposits that either outcrop or are covered by minimal amounts of non-mineralised material (overburden), occur in the northern half of the Premises. Mid-level deposits are covered with varying depths of overburden. The basement deposits occur below the mid-level deposits and are typically more weathered and of lower heavy mineral grade.

### 6.3.2 Landform and soils

The Premises is located within the Swan Coastal Plain geomorphological division and is

[5] Previously described as the Munbinea shorelines.

situated on the Bassendean sand complex. This complex is characterised as a gently undulating landscape consisting of sand dunes, inter-dune basins and swales. Dissected remnant hills bound the Premises to the east.

Soils within the Premises are divided into two zones: surface sands and a deeper clay layer. Seven soils have been identified across the Premises and grouped into three soil associations corresponding to different geomorphic zones:

- Soils of the gently undulating, lateritised surface – comprised of sands overlying ferruginous gravel, deep white sands and pale grey, light clays;
- Soils of the dune fields – comprised of deep white sands and deep yellow sands; and
- Soils adjacent to Mullering Brook – comprised of clayey sand, deep gradational sands and shallow clayey sands.

The soils on the Premises are generally low in nutrients. The organic content is moderate in the topsoils but nutrients are quickly leached from the sandy soils. The sandy soils have high infiltration and limited capacity for water retention, which causes soil moisture availability to be one of the key limiting factors in plant growth.

## 6.4 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 are shown in Table 13.

Table 13 also identifies the distances to other relevant ecosystem values which do not fit the definition of a specified ecosystem.

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

## 6.5 Hydrogeology

The Premises lies immediately to the west of the Gingin Scarp which forms the eastern margin of the Bassendean Dunes geomorphological unit. The Bassendean Sand forms part of the Superficial formations, a collective name to describe the near surface sediments of the Perth Basin, and includes the mineral sand deposits that are the target of the mining operation.

The Premises is underlain by an extensive and complex groundwater system that varies considerably from the south to the north mine areas. There are two major aquifer systems that host the aquifers within both mining areas:

- The Superficial Formation, which is traditionally regarded as an unconfined aquifer, but is confined to semi-confined particularly in the central and southern parts of the Premises; and
- The Yarragadee Aquifer, which is traditionally regarded as a confined aquifer, but is semi-confined in the North Mine area.

The stratigraphy in each area is described in Table 14.

**Table 13: Environmental values**

| Specified ecosystems | Distance from Prescribed Activity |
|---|---|
| Geomorphic wetlands – Cervantes South | Wongonderrah Swamp –approx. 900 m north of Falcon Extension |
| | Wongonderrah Spring |
| | Wandamurra Spring |
| | Coonmadodo Swamp –approx. 12 km west of South Mine |
| | Frederick Smith Creek –approx. 10 km west of North Mine |
| | Cooljarloo Swamp – approx. 6 km west of South Mine |

| | |
|---|---|
| | Caro Swamp –approx. 6 km south of South Mine |
| | Muralang Pool |
| DBCA-managed lands and waters:<br>‘Class A’ Conservation Reserves | Badgingarra National Park – approx. 4 km north-east of North Mine |
| | Nambung National Park –approx. 12 km north of North Mine |
| | Minyulo Nature Reserve |
| | Eneminga Nature Reserve |
| | Unnamed Nature Reserve (R40916) |
| DBCA-managed lands and waters:<br>‘Class C’ Conservation Reserves | Wongonderrah Springs Nature Reserve – immediately north of North Mine |
| | Unnamed Nature Reserve (R27993) |
| | Wanagarren Nature Reserve |
| | Unnamed Nature Reserve (R41986) |
| | Mullering Brook Nature Reserve |
| Ecological Communities (TECs and PECs) | Priority 1 – Claypans with mid-dense shrublands of *Melaleuca lateritia* over herbs.<br>One floristic community (T5) recorded as part of flora surveys for the Cooljarloo West proposal may represent this PEC; however additional surveys would be required to confirm this. |
| **Biological component** | **Description** |
| Threatened/Priority Flora | A total of 34 DRF and priority flora species were recorded within and/or in the vicinity of the Premises between 2005 and 2009 as part of vegetation surveys for the Cooljarloo West proposal<br>A number of poorly known taxa and range extensions have also been recorded within and/or in the vicinity of the Premises.<br>Refer to Appendix 3 for full list. |
| Threatened/Priority Fauna | A total of 18 fauna species of conservation significance have been recorded within and/or in the vicinity of the Premises as part of terrestrial fauna studies since 1986.<br>Refer to Appendix 3 for full list. |

### 6.5.1 Superficial aquifer

The superficial formations host the broad, predominantly heterogeneous superficial aquifer, which is typically confined to semi-confirmed across the southern and central parts of the Premises, and typically hosted within sedimentary units of varying characteristics and permeability. The typical distribution of superficial formations across both mine areas are shown in Table 14.

The distribution of the superficial formations varies significantly between the ‘north’ and ‘south’ mine areas. In the ‘south’ mine area, the Bassendean sand, Guildford and Yoganup formations comprise alternating layers of sands and clays; the sands are moderately permeable while the clays have a low permeability that may present a barrier to groundwater flow. Clay zones near the surface can cause perched water tables that result in waterlogging and seasonal damplands or wetlands. In some areas, the deeper sands contain significant clay layers that inhibit groundwater flow. In the ‘north’ mine area, these formations are absent and are replaced by heterogeneous sands and silts. Across the ‘north’ mine footprint, peat layers intersect these horizons creating a heterogeneous regional aquifer.

**Table 14: Generalised hydro-stratigraphy of the South and North mine areas (MWES, 2016; PPK, 2001a)**

| Group/ Formation | Typical depth interval (mbgl) | Lithology | Aquifer name and properties |
|---|---|---|---|
| ***North Mine*** | | | |
| Superficial formations | Variable. Thickening from northeast (~18 m) to southwest (~40 m ) in the North mine area | The profile is predominantly sands and silts, distinctly inhomogeneous and changes over relatively short distances. Peat layers are commonly intersected, and have a profound effect on local groundwater quality in the superficial aquifer.<br>If clay layers occur, they tend to be thin and in discontinuous lenses. The clayey layers that represent the regional Guildford clayey silts appear to have been eroded from the superficial formations by a later alluvial episode. | Superficial aquifer:<br>Groundwater flow moves east to west in response to the regional groundwater gradient.<br>This “unconfined” nature of the superficial aquifer in parts of the area provides opportunity for recharge from direct precipitation. |
| Yarragadee Formation | >40 m to 450 m | Comprises massive interbedded coarse sandstones, siltstones and shale units. Seismic profiling indicates the bedding is almost horizontal in the area.<br>The current North Mine pit exposes the Yarragadee Formation at the base and in the east wall of the excavations. This palaeo-sea cliff trends north-south and separates a thin overlying layer of superficial formations sands to the east, from more complex superficial stratigraphy thickening to the west. | Yarragadee aquifer:<br>Major aquifer. Under natural conditions piezometric heads indicate an upward hydraulic gradient. Groundwater seeps upward from the Yarragadee and recharges the superficial aquifer. |
| Cattamarra Coal Measures | 450 m + | Comprises siltstones, shales and coal seams below a large fault zone. May represent upthrust wedges of basement formations as mapped to the west. | Cattamarra Coal Measures:<br>Minor aquifer. Intersection of the formation resulted in release of hydrocarbon gas and breakdown of drilling mud due to pH and salinity effects. Forms an effective base to productive upper aquifers in the area. |
| ***South Mine*** | | | |
| *Superficial formations* | | | |
| Bassendean Sand | 0 – 6 m | Dry, white to orange brown, loose to medium dense, fine grained sands. Ferruginisation, toward the base and a ferricrete pebble layer of variable thickness, is associated with a perched water table. | Surficial aquifer:<br>Potential perched systems. Perched water is erratically associated with a ferricrete gravel layer occurring at the base of the recent Aeolian sand cover. Seeps can be seen in the dredge pond slopes, preferentially associated with depressions in the surface of the underlying clayey layer. |
| Guildford Formation – clay facies | 6 – 20 m | Slightly moist, pinkish orange to grey, dense clayey and silty fine sand. Several plastic clay layers ~1 m thick occur in the profile. | Aquitard, thickness and distribution can be variable. |
| Guildford Formation – sand facies | 20 – 35 m | Saturated, light white and grey slightly clayey silty fine sand coarsening downward becoming fine to medium grained close to the base. | Superficial aquifer:<br>Confined to semi-confined minor aquifer. The upper finer sands of this unit tend to “leak” water into the lower productive portion of the aquifer under pumping conditions. |
| Yoganup Formation equivalent | 35 – 50 m | Saturated, light grey, sands with heavy minerals, coarsening down until close to the base as they become medium to coarse often with flakes of white feldspar. A few metres of very coarse, gravely sands may be present at the base. | Superficial aquifer:<br>Aquifer. Transmissivity: 55 – 85 $m^2$/day. |
| Yarragadee Formation | 50 m + | Dirty brown or yellow, clayey sands and siltstones of the Yarragadee Formation. Variable composition over short distances, although the formation has not been penetrated to any significant depth. | Yarragadee aquifer:<br>Upward head gradient (minor). |

Groundwater flow is predominantly from east to west, except where influenced by mining activities and prolonged groundwater abstraction. Hydraulic gradients identified in numerous multi-level monitoring bores across both the Yarragadee and Superficial aquifers note the upward trend of groundwater movement. Within the North mine area however, downward leakage is induced in areas with significant groundwater abstraction from the Yarragadee aquifer.

Groundwater recharge is thought to occur via three main mechanisms: direct recharge via rainfall; localised upwelling of groundwater from the underlying Yarragadee aquifer, where it is hydraulically connected; and through-flow from the Gingin Scarp located to the east of the Premises.

#### Groundwater levels

There is a regular east to west regional trend of groundwater levels in the Superficial aquifer, decreasing across the Premises from a high of 115 mAHD in the east to a low of 30 mAHD in the west. This trend conforms to the topography from the higher elevations of the Gingin Scarp to the east.

Some localised disturbance and flattening of the regional water levels occurs between the 60 and 70 m contour lines, due to dewatering activities and is most pronounced near the grouping of production bores in the southern mine area.

#### Groundwater quality

Pre-mining baseline data indicates that water quality within the Superficial aquifer ranges from around pH 3.4 in the north mine area to a maximum pH 5.9 in the south mine area. Seasonal variations in salinities are evident in the Superficial aquifer and are inherently higher towards the north-west of the site. Baseline salinity levels range from 514 mg/L TDS in the south mine area to 3,214 mg/L TDS in the north (increasing further north in the Falcon project area).

### 6.5.2 Yarragadee aquifer

The Yarragadee aquifer unconformably underlies the Superficial Formations between 30 and 50 m below ground surface over most of the Premises. The upper surface of the Yarragadee Formation, immediately below the unconformity at the base of the Superficial Formation, is weathered sand. There is also a 1 to 3 m thick silty and sometimes clayey layer formed discontinuously below the unconformity. Water quality markedly declined below 140 m depth.

Groundwater flow modelling and groundwater level monitoring on the Premises indicates the Yarragadee and Superficial aquifers are in hydraulic continuity.

Formations comprising the Yarragadee aquifer vary in composition from thin shale and coal units, to clean siltstones and thick coarse-grained sandstones with a high degree of primary porosity and permeability.

### 6.5.3 Perched aquifer

According to PPK (2001a), perched water occurs erratically across the South Mine area, associated with a ferricrete gravel layer occurring at the base of the recent Aeolian sand cover. Monitoring has indicated an average of 1 m seasonal variation, with the perched aquifer most likely recharged by direct precipitation, but could also derive water from the Superficial upwelling through areas where the Guildford clays are thin or absent.

Concerns have been expressed about the potential for impacts to a series of low lying dampland areas that occur to the west and south of the dredge pond, through the dredge pond excavations interrupting perched aquifer flow across the site from east to west.

## 6.6 Surface water

The Dandaragan Plateau drains the region surrounding the Premises, including the Nambung River, Mt Jetty Creek, Mullering and Minyulo brooks.

Surface water occurs across the Premises in the form of ephemeral streams and damplands, as permanent watercourses are generally limited by the permeable surface sands and dry climate. Two watercourses pass through the mining lease, while lesser drainage lines carry intermittent flows from the Gingin Scarp onto the lease area where they dissipate in the sandy soils (Table 15). Several permanent and seasonal lakes to the south-west occur in inter-dunal depressions in the Bassendean dunes, such as Emu Lakes.

**Table 15: Surface water and water sources**

| Surface water and water sources | Distance from Premises | Environmental Value |
|---|---|---|
| Mullering Brook | Passes through the mine lease area from east to west across Mullering Farm | Seasonal watercourse that passes through active mining areas (current and historical) and has been diverted several times<br>Flows for less than 4 months per year, typically during winter. Average flow rates 5.0 $m^3$/sec and total volumes in the order of 2 million $m^3$<br>Water quality is variable, ranging from 1,000 to 3,000 mg/L TDS |
| Mt Jetty Creek | Crosses the NE corner of the Premises boundary | Ephemeral creek line that drains a catchment to the east of Wongonderrah Nature Reserve, forming a tributary to the Nambung River |
| Minyulo Brook | ~ 1 km south of the southern Premises boundary | Ephemeral creek line that flows south of the Premises and terminates in Emu Lakes |
| Emu Lakes | Abuts the SW corner of the Premises boundary | Permanent lake |

## 6.7 Biological environment

The Premises is located within the Swan Coastal Plain bioregion in accordance with the Interim Biogeographic Regionalisation for Australia classification system.

### 6.7.1 Vegetation and flora

Numerous flora and vegetation studies have been undertaken within the mining lease and surrounding areas for the purposes of managing rehabilitation under the Ministerial Statements.

Consistent with native vegetation of the Northern Perth Sandplains, UCL areas within the Premises are considered to have a high biodiversity value, comprising a diverse range of upland and wetland communities that are commonly referred to as Kwongan[6].

The vegetation system over the Premises consists mainly of banksia low woodland of various types with areas of wetland heath and mixed low heath of relatively high conservation value.

A number of Declared Rare and Priority flora species are known to occur across the Premises – the majority of which are extensively represented in local areas and protected in conservation estate.

### 6.7.2 Fauna

Banksia woodlands present within the Premises provide suitable habitat for a range of terrestrial fauna species.

[6] Kwongan typically includes heath and woodland elements and is known for high species diversity and a high degree of endemism. Kwongan vegetation is adapted to the nutritionally impoverished sandy soils and the growth form of plants is principally determined by the availability of soil moisture.

Recent faunal surveys in UCL west of Mullering Farm for the Cooljarloo West proposal have recorded a large number of vertebrate fauna, including species of fish, frogs, reptiles, birds and mammals. The faunal assemblage is typical of the region, and includes a number of species of conservation significance (refer to Appendix 3).

### 6.7.3 Wetlands and groundwater dependent ecosystems

Wetlands within the Premises form an element of the Minyulo Suite, which are a group of consanguineous wetlands comprising the Mullering and Minyulo brooks, Emu Lakes and smaller sumplands, damplands and seasonal creeks located between brooks within the Bassendean dunes. The Mullering and Minyulo brooks are both regionally significant as they support a high proportion of water dependent flora and act as a flushing mechanism for associated wetlands.

Wetlands within the Premises can be highly variable in terms of appearance and composition. Multiple wetland vegetation communities have been identified within the Premises that are associated with the complex soils and stratigraphy of the region.

The closest known groundwater dependent ecosystem (GDE) to the Premises is known as Cooljarloo Spring (site 76), which comprises Guildford Sands and alluvium associated with a shallow watertable.

Banksia woodlands, which factor prominently within the Premises, have been the subject of several studies that have assessed the groundwater dependence of composite species.

## 6.8 Physical environment

### 6.8.1 Climate

Cooljarloo 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).

### 6.8.2 Wind direction and strength

The nearest Bureau of Meteorology weather station is located at Badgingarra Research Station (Site number 009137), approximately 38 km north-east of the Premises.

The average wind direction at 9 AM and 3 PM is presented in Figure 9. The following wind roses represent the various percentage of wind occurrences recorded during the period 1965 – 2010.

The graphs illustrate predominantly moderate winds from the east/north-east in the mornings, shifting to moderate afternoon west/south-westerly winds in the summer and winter months, respectively.

### 6.8.3 Rainfall and temperature

During 2015, total precipitation was 399.6 mm, which has been the driest year since the commencement of records for the site in 1990. Sporadic rainfall was encountered during the summer months, however below average winter rains were the primary cause for the below average annual rainfall.

Over the last 25 years, there has been an overall declining trend for precipitation received at the Premises, with the average annual rainfall being 546.1 mm.

Rainfall is the lowest in December, with an average of 8 mm. Most of the precipitation falls in July, averaging 101 mm (Figure 10). There is a difference of 123 mm of precipitation between the driest and wettest months. Throughout the year, temperatures can vary by 12.4 °C.

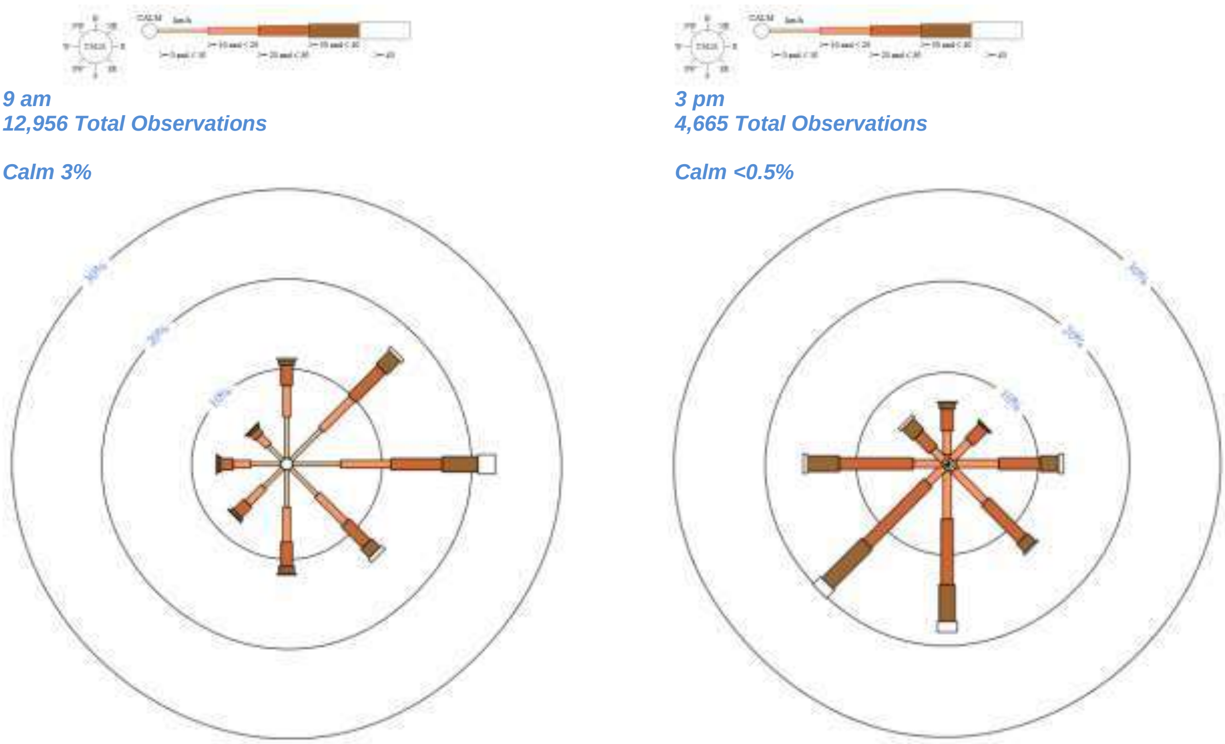


***Figure 9: Wind roses, Badgingarra 1965 – 2010 annual average at 09:00 am and 3:00 pm***

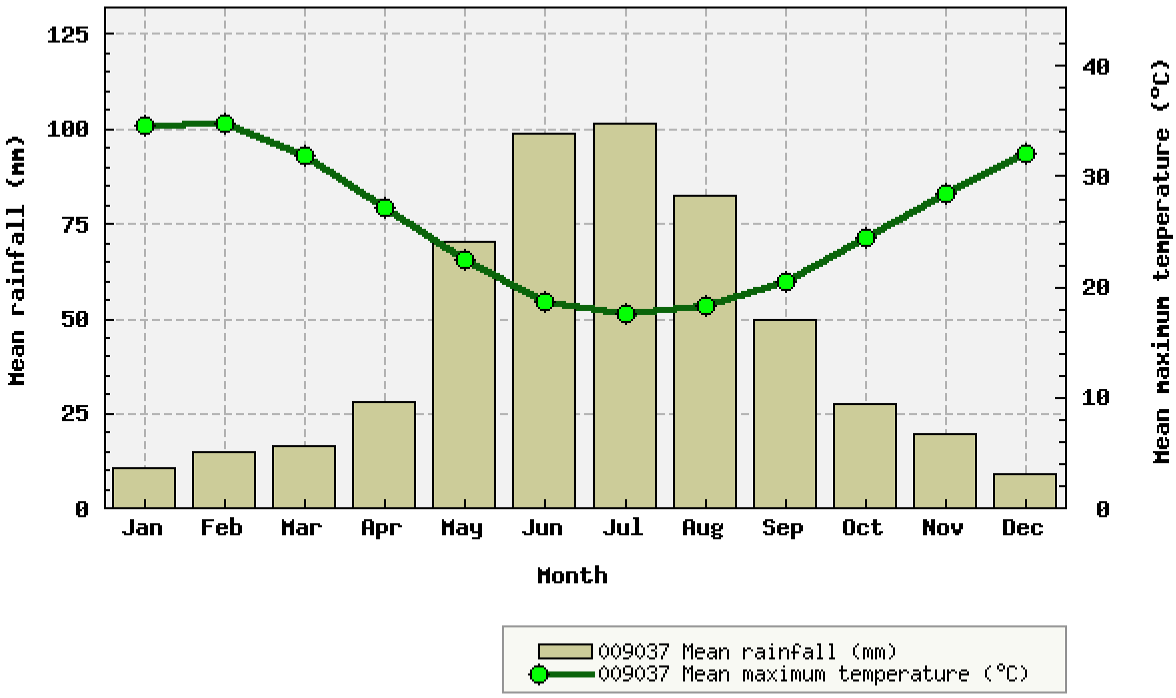


***Figure 10: Average rainfall and maximum temperature for Badgingarra 1962 – 2017***

# 7. Modelling and monitoring data

## 7.1 Acid sulfate soils

Acid sulfate soils (ASS) are present across the site (SWC, 2015). The licence holder has undertaken two major ASS investigations to date, the first was related to the Falcon dry mining extension project at the North Mine (2007, as cited in Tronox, 2013), and the second relating to the South Mine operations (SWC, 2015).

Based on these reports, materials present in the north of the Premises are different from those located in the southern portion of the Premises, in terms of acid generating potential (Arcadis, 2017). The findings of the 2007 investigation indicated the presence of ASS within the soil profile (black/grey clays) at depths >2 m below the area to be mined, whereas the findings of the 2014 investigation indicated an abundance of sulfides within the South Mine area, which together with a lack of buffering capacity, is generating a highly acidic tailings stream.

### 7.1.1 South mine operations

Pre-mine screening has been undertaken during resource definition at the 'south' mine since 2010, with the latest drilling campaign being in October 2014. During this period, a total of 1,093 samples from 84 drill holes were taken across a future mine area of 163 ha, with the majority drilled into the in-situ profile to depths around 32 mbgl.

The key results from the sampling and associated analytical testing included:

- in-situ field pH ($pH_F$) values for all samples tested varied from 2.9 to 8.4, indicating that oxidation of sulfides has occurred. Samples with a pH < 4 were restricted to the surface 3 – 11 m of the in-situ profile and comprised < 2 % of the total number of samples tested;
- oxidised field pH ($pH_{FOX}$) values for all samples tested varied from 1.1 to 5.9, with the majority (70 %) returning $pH_{FOX}$ results of < 3, indicating an abundance of sulfides in the near surface horizons across the South Mine operations;
- approximately 25 % of samples tested were collected from within the existing fines dams, adjacent to the dredge pond, or along embankment walls. None of the samples were classified as Actual ASS (any sulfides present appear to have remained in a predominantly unoxidised state);
- the soils throughout the South Mine contain negligible alkalinity and have effectively no buffering or acid neutralising capacity;
- results of Chromium Reducible Sulfur ($S_{CR}$) testing have indicated low actual sulfide content (i.e. < 0.03 % - below current DWER trigger levels). Low $pH_{FOX}$ values following oxidation is thought to have occurred in response to the dominance of quartz and the absence of any buffering capacity of the soil; and
- results of acid base accounting using the $S_{CR}$ values has indicated that small amounts of acidity are being generated from 'trace' sulfides.

### 7.1.2 Targeted investigation of the dredge pond

From the end of 2011 the pH of the dredge pond started to drop, followed by a rapid decrease to around pH 3.1 in July 2013 (Figure 11). The lack of a buffering response following the addition of a significant quantity of neutralising agent (lime putty) prompted a targeted investigation into the key driver causing the observed acidity.

The key results from the investigation conducted by SWC (2015) are summarised below:

- the issues observed in the dredge pond are principally ASS-related, exacerbated by high levels of fines in the pond. The small amounts of acidity generated from 'trace' sulfides either during processing and fines generation, and the absence of any buffering capacity, has resulted in the accumulation of a significant quantity of acidity released into the dredge pond, which has resulted in the primarily kaolinitic fines material becoming highly positively charged;

- the nature of the surface charge, the very high surface area to volume ratio, and the substantial fines content in the dredge pond, had resulted in a poor response to the addition of lime putty, and represents significant challenges to neutralisation;
- the ultimate solution to address the issue will involve significantly desliming the pond and then to maintain a low solids ratio – the issues will remain if the fines content remains at current levels, irrespective of whether non-PASS material is mined; and
- there is residual unoxidised acidity (i.e. PASS) present in the fines material in the dredge pond, which will likely limit the success of near surface rehabilitation, given its potential to oxidise further (to pH values < 3).

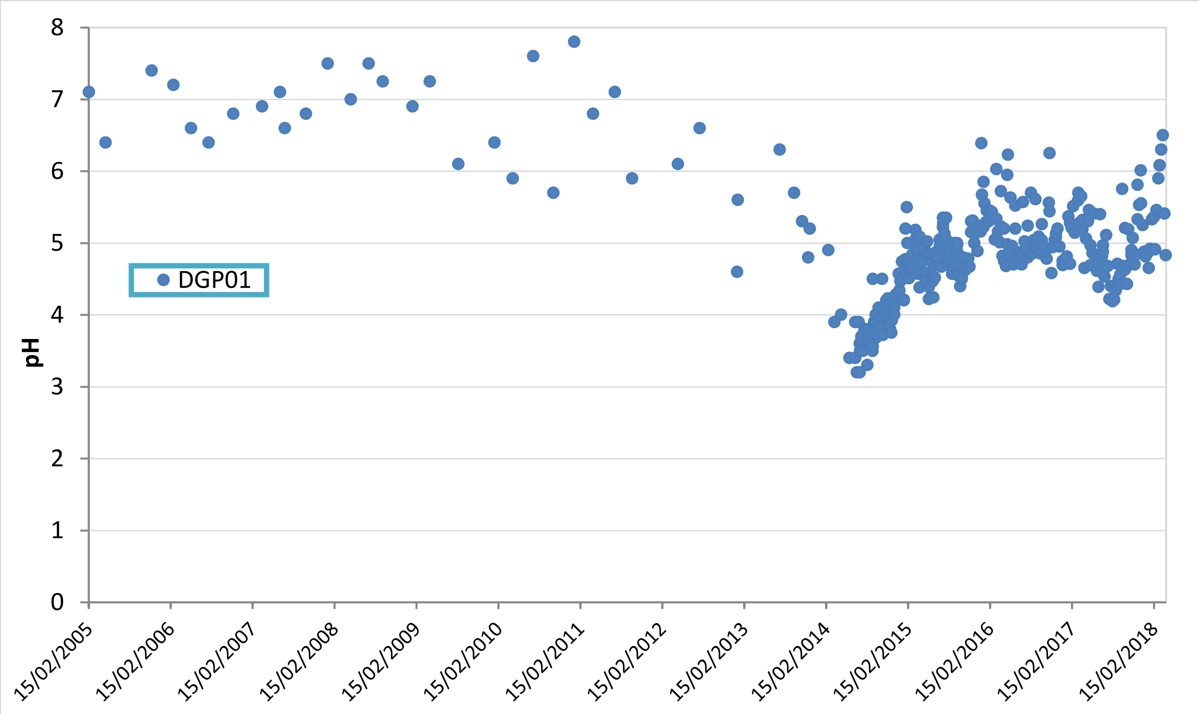


***Figure 11: pH of the dredge pond 2005 – 2016***

In response to the investigation outcomes, the licence holder has attempted to increase the pH of the dredge pond by continuously treating it with slurried lime and progressively pumping the clay fines from the pond to discrete solar drying ponds. These treatments have resulted in a steady increase in the dredge pond pH, which is currently being artificially maintained between 4.5 and 5.5.

### 7.1.3 DWER technical review

DWER's review of the South Mine ASS Management Plan (SWC, 2015), which includes baseline, pre-screening work undertaken in current and future mine areas, as well as results from the targeted investigation into the acidification of the dredge pond, identified that:

- the investigations conducted were carried out in an appropriate manner, and the conceptual site model developed for the South Mine operations for determining the distribution of sulfide minerals in the deposit is also considered to be sound;
- the progressive pumping of clay fines from the pond, and from current processing, to external locations, should continue as a remedial action to ensure a low solids ratio can be maintained in the dredge pond;
- although the addition of an acid neutralising agent (slurried lime) has subsequently raised the pH to about 5.0, this is still too low to prevent the leaching of some metals and radium from fine sediments into solution. It is particularly important the pH is maintained above 6.0 to reduce the risk of radium being desorbed from the clay fines and released into groundwater. It is therefore recommended the rate of lime addition to the dredge pond be increased to achieve this objective;

- other measures that could be implemented to reduce the risk of metal and radium leaching from mine wastes include:
  - assume the entire South Mine orebody has a $S_{Cr}$ content of >0.03 % S and lime treat accordingly to the dredging operation (i.e. in-line liming during dredging). This should ensure that sufficient lime is available to neutralise any excess acidity that may be produced by the oxidation of sulfide minerals; and
  - in addition to pH measurements, measure the total acidity and total alkalinity of the water in the field (i.e. using commercial test kits that are cheap and simple to use). This is because changes in acidity and alkalinity are typically seen in an acidifying water body long before pH changes take place (i.e. management response such as increasing lime dosing can be implemented more quickly by measuring these parameters). In particular, water that has an alkalinity of less than 10 – 30 mg/L $CaCO_3$ has the potential to experience large pH declines with the input of small amounts of acidity. It is also recommended the alkalinity of the dredge pond is maintained above 30 mg/L $CaCO_3$ to reduce the risk of further acidification taking place.

**Key findings:**

1. The progressive decline of the pH of the dredge pond from about 6.5 -7 in 2011 to less than 4.0 in 2014 indicates that sulfidic mine wastes have not been adequately managed at the site.
2. The addition of an acid neutralising agent (slurried lime) to the pond has subsequently raised the pH of water in the pond to around 5.0, however this is still too low to prevent the leaching of some metals and radium from fine sediments into solution. It is therefore recommended the rate of lime addition be increased (or other measures implemented) to achieve this objective.

## 7.2 Groundwater monitoring

Groundwater has been predominantly overseen by DWER under the RIWI Act, with ‘preventing unapproved impacts to the environment and/or other groundwater users from mine-related groundwater use’ being the key objective.

The Cooljarloo EMP outlines the management of risks relating to groundwater abstraction and dewatering at the Premises, including impacts to groundwater dependent vegetation and other users from groundwater drawdown, and groundwater quality due to the oxidation of PASS (caused by groundwater drawdown).

The GOS for the Premises (PB, 2015) compliments the EMP by providing further detail on the management of water resources and related risk, including monitoring and measurement of performance (against controls applied to manage specified risks).

### 7.2.1 Current monitoring requirements

The monitoring program is mainly structured around potential impacts to the groundwater resource, associated with production bore pumping and dewatering, with less of an emphasis on potential groundwater contamination caused by mining activities, e.g. previously dredged areas, tailings disposal areas, etc. It appears in the past that Part V Licensing has had minimal involvement with the groundwater monitoring program, most likely on the assumption the EPA and/or the former-DoW would oversee all issues relating to groundwater.

A summary of current monitoring obligations, relevant to potential groundwater contamination, are shown in Table 16.

**Table 16: Groundwater monitoring obligations (redacted) under the Groundwater Operating Strategy (PB, 2015)**

| Management objective | Monitoring point | Parameter | Frequency |
|---|---|---|---|
| **Objective:**<br>Groundwater quality within the range of pre-mining background values for that groundwater area<br><br>**Management trigger:**<br>Water quality trending outside pre-mining background levels | **GDV observation:**<br>Superficial: DGP 01, MSB 04, NBF 09s, NVMB 03s, 04s, 15, OB 32<br>*Within the vicinity of predicted groundwater drawdown and in GDV areas* | pH<br>Electrical conductivity<br>Total dissolved solids<br>Major ions and anions: carbonate, bicarbonate, hydroxide, calcium, magnesium, potassium, sodium, chloride, sulfate, nitrate<br>Metals and metalloids: aluminium, arsenic, barium, chromium, cadmium, copper, iron, lead, manganese, mercury, nickel, selenium, titanium, zinc | Quarterly |
| | **Pre and Post mining observation bores:**<br>Superficial: MBS 13, MSB 03, 05, 07, 10d, NAMD 01, 02, OB 07, 14, 15d, 18d, 20s/d, 23s/d, 28<br>*Within an area of historical drawdown and near areas of GDVs* | | 6-monthly |
| | **MRF observation bores:**<br>WMB 01A, 02C, 06sB, 07d, 09, 11d, 13, 14<br>*Adjacent to the Mineral Residue Facility* | | Quarterly |

### 7.2.2 Monitoring results

Results of groundwater monitoring in the Superficial Aquifer that are relevant to this Review from the previous triennial reporting period (2013 – 2015) are summarised below. Long term trends are also briefly discussed.

#### Groundwater quality trends

According to HGEO (2018), groundwater salinity within the overall Superficial Aquifer typically ranges between 200 and 30,000 µS/cm, however within that broad range each operational area has a more restricted and characteristic range in EC. There is a general increase in groundwater salinity from the south to the north, which reflects a pre-mining spatial trend controlled by the aquifer characteristics and proximity to the Dandaragan scarp.

<u>North Mine borefield</u> – The Falcon area has the highest groundwater salinity (on average), which is considered to be caused by natural salinisation and ion exchange with clay minerals in proximity to the fault escarpment (HGEO, 2018).

Throughout 2016-17, several bores located west of the former dry mining operation at "Site 12" recorded elevated salinity values >4,000 µS/cm. Some shallow bores displayed an increasing-decreasing trend, which is thought to be due to rainfall recharge during winter.

Groundwater pH ranges from acidic to mildly alkaline (3.4 to 8.1). Several bores located close to the "Site 12" mining area that are displaying the lowest pH values have been identified as being screened within PASS material (discussed below).

<u>South Mine borefield</u> – Groundwater salinity generally varies between 490 and 4,310 µS/cm, however some observation bores show values around 9,600 µS/cm. Groundwater pH within this area is acidic to neutral, with pH ranging from 3.4 in bore MSB05 to 7.6 in MSB02. Bore MSB06A also has a low pH of 4.5.

Elevated salinity (up to 15,000 µS/cm) was noted in bore MSB05A during 2015-16, and was associated with an increase in $SO_4$/Cl ratio and a decrease in pH. An investigation by SWC (2017) found there was appreciable PASS material on the western side of "Site 12" – an area that was dry mined during 2013 – December 2015 – and that monitoring bores in the area are screened within PASS material. Declines in groundwater levels, predominantly due to dewatering activities at "Site 12", has resulted in oxidation of PASS material and a subsequent decrease in pH (acidification) and increase in EC and $SO_4$/Cl ratio. Following the suspension of dry mining in December 2015, the water table has returned to pre-mining levels and water quality has improved.

The MSB10 series of bores, located immediately upgradient of the MRF, have shown a significant and persistent increase in EC since monitoring first commenced in 2000 (refer to section 7.2.3).

### 7.2.3 Impacts on groundwater quality

An assessment of potential impacts on the environment from the groundwater regime is provided within the annual/triennial aquifer reviews. A summary of identified impacts relevant to this Review are provided below.

#### Groundwater observation bores

High salinity groundwater has been observed across the Premises, notably:

- in the Falcon mine area, high Cl groundwater is found in several of the observation bores. The high salinity is thought to be natural to the area and caused by the proximity of swamplands and up-flow of saline groundwater from the underlying Cattamarra Coal Measures;
- elevated salinity in bore MSB05/5A is considered to be attributed to lateral movement of saline water from the Site 9 process water ponds;
- increasing salinity in bore MSB10D, located in the South Mine area (discussed below); and
- some bores in the North Mine area have elevated salinities, and are thought to be associated with elevated sulfates.

#### Dredge pond water quality

The salinity of the dredge pond has increased from around 1,400 µS/cm prior to late 2013 to above 2,600 µS/cm by mid-2015. At the same time, the pH had dropped below 4 – this is discussed above in section 7.1.2.

Salinity peaked at 9,750 µS/cm during 2015, however has remained stable between 2,110 and 2,910 µS/cm during 2017.

#### MSB10 monitoring bores

As mentioned above, a significant increase in EC was noted in the most recent triennial aquifer review (MWES, 2016) for bore MSB10D.

Historically, salinity levels fluctuated between 230 and 4,630 µS/cm in the original MSB10 bore until it was replaced by MSB10C in 1994-95. Salinities fluctuated between 920 and 3,150 µS/cm in MSB10C until it was replaced by the current MSB10D in 1996-97. Salinities in MSB10D were low in the range 490 to 1,100 µS/cm, before rising to around 2,800 µS/cm in 2014 (Figure 12).

An investigation conducted in 2016 (MWES, 2016) concluded that groundwater salinity is likely to have risen due to gradual migration of a saline groundwater plume from beneath the MRF. The specific source of the salinity was not proven, however the groundwater has a similar chemical signature to other bores, WMB07D and WMB12D, located downstream of a black waste pit used in 1993. MWES (2016) recommended further investigation of this issue.

#### Mineral Residue Facility monitoring bores

The WMB series of bores, located in proximity to the MRF, indicate a slightly acidic to neutral pH (6 – 7.25) and an increasing trend in groundwater salinity, although the majority of the salinity values are within the historical range. However as noted by PPK (2001), the distribution of the WMB series of bores in relation to the black waste pits does not provide a clear understanding on groundwater impacts caused by the waste pits. Waste Pit 1 is currently over-monitored and there is minimal information being collected from the other pits, particularly downgradient of Waste Pits 6 and 7. Additionally, in the absence of detailed hydrogeological information, there is considerable uncertainty as to whether the bores are suitably located and constructed to detect leachate that might discharge from the waste pits, particularly the earlier (unlined) pits.

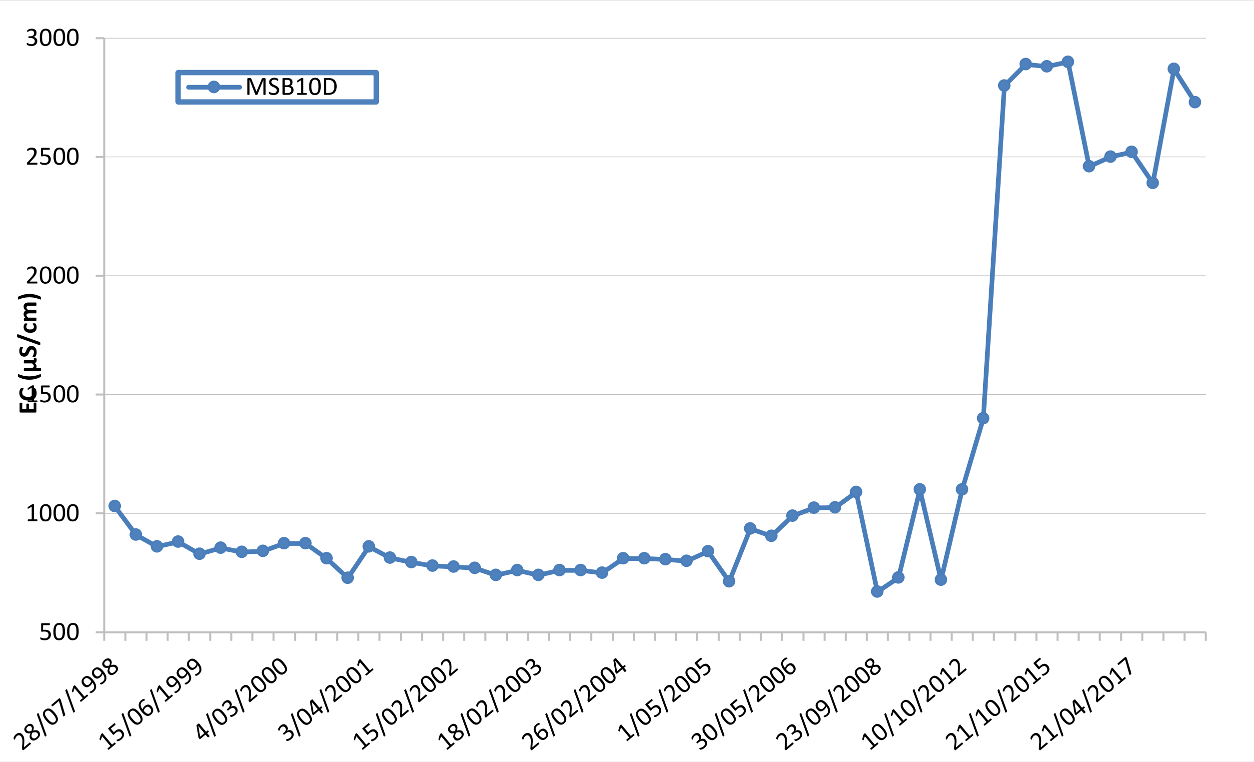


***Figure 12: Groundwater salinity MSB10D***

## Geochemical modelling

In response to concerns raised by DWER early in this review process, the licence holder commissioned geochemical modelling of the dredge pond to establish the potential interaction with the surrounding aquifer (SWC, 2019). The modelling was undertaken using PHREEQC, which considers solute speciation, mineral equilibrium, ion exchange and surface complexation reactions in predicting the fate and transport of solutes. It also involved the development of a conceptual model based on the current understanding of the aquifer properties and site layout.

Key findings from the modelling conducted by SWC (2019) are summarised below:

- impacts from the dredge pond historically are likely to be either spatially restricted to within 400 m of the pond boundary, or temporary in nature, with background water levels returning after the dredge pond water ‘pulse’ has passed by;
- the aquifer properties act to slowly neutralise the incoming dredge pond water which is at a lower pH than the surrounding aquifer water. The scale of the neutralising effect diminishes as the incoming dredge pond water pH approaches the pH of the aquifer water, therefore beyond a certain pH range of around 5 and above, raising the pH of the dredge pond will have little effect on the impact to the surrounding aquifer due to the exponential reduction in differential pH;
- the modelled results for pH, $SO_4$, Cl, Al and Fe resemble those concentrations reported in actual groundwater bores located downstream of the dredge pond, and the predicted

levels/concentrations are all within the range reported in the local region – the PHREEQC modelling is therefore considered to be accurate and is predicting actual geochemical processes occurring at the site; and

- the results can be extrapolated to predict the impacts from other pit voids, including Site 12 and Site 19.

### 7.2.4 DWER technical review

DWER has reviewed the available information on groundwater, including the South Mine ASS Management Plan (SWC, 2015), the most recent Annual Aquifer Review (HGEO, 2018) and Triennial Aquifer Review (MWES, 2015), the Cooljarloo Groundwater Operating Strategy (Parsons Brinckerhoff, 2015), geochemical modelling (SWC, 2019) and available groundwater monitoring data, and considers the following:

- DWER generally supports the observations made by MWES (2015) that the high groundwater salinity values observed in some monitoring bores in the area are due to a combination of natural and mine-derived sources of solutes, however the use of the sulfate/chloride ratio to distinguish between "natural" salinity and salinity derived from sulfide oxidation caused by mining activities is problematic. The groundwater monitoring data indicates the sulfate/chloride ratios of saline bores in the Falcon area are highly variable, suggesting that sulfide oxidation is also naturally taking place in oxidising wetland sediments in the area. This may be a fairly recent phenomenon linked with the regional drying of wetlands in the area as historical investigations in the 1990s by Kern (1993) found that elevated groundwater salinities in the area generally had a very low sulfate/chloride ratio. Many bores in the region also have low alkalinity values (<50 mg/L $CaCO_3$) suggesting that acidity is being released by sulfide oxidation which is reducing the buffering capacity of groundwater in the area;

- In general, the conceptual model and the assumptions used to develop the reactive-transport model are considered to be sound, although the boundary conditions used are constrained by the one-dimensional nature of the model. Additionally, the ion-exchange capacity of the aquifer matrix that has been assumed seems to be high for the predominantly sandy sediments that underlie the Cooljarloo site, although this would only affect the rate of transport of chemical constituents in groundwater. The modelling was undertaken in an appropriate manner and, within the constraints of the assumed boundary conditions, the model conclusions are supported.

  That is, DWER agrees with the overall conclusion of the modelling that, under the current hydrological regime at the site and with the exception of sulfate levels, environmental impacts from seepage from the dredge pond are likely to be mostly constrained to groundwater within a few hundred metres of this structure. Elevated sulfate concentrations could persist in groundwater for much larger distances than other chemical constituents due to the limited availability of organic carbon in aquifer sediments to allow sulfate-reduction to take place to form sulfides.

  However, impacts on groundwater quality are only likely to be localised under conditions where the elevation of the water table near the dredge pond only shows small seasonal variations. Reactive-transport modelling supported by groundwater investigations in similar sandy sediments in the region (Salmon *et al*., 2014) have shown that pyrite oxidation and metal release from aquifer sediments can take place when the water table progressively declines. This can cause the release of acidity and metals from sandy sediments in the region, even under conditions when the initial water table elevation is located at depth below the ground surface.

  This means that, under conditions where the elevation of the water table is falling due to decreasing annual rainfall or increasing groundwater abstraction, the plume from the dredge pond could travel much further in groundwater at the Cooljarloo site than predicted by the PHREEQC model. This is because the capacity of aquifer sediments to attenuate groundwater concentrations of some chemical constituents would be greatly reduced by the acidification process.

- The tolerance of local native plants to low pH conditions is not necessarily a good indicator of their ability to resist prolonged acidification when sub-soils and aquifer sediments become depleted in base-cations such as calcium-ions, and cation exchange-sites in these materials are replaced by soluble aluminium (Appelo and Postma, 2005). For instance, acidification on the Gnangara Mound appears to be locally causing a significant loss of calcium ions from soils and shallow groundwater into deep groundwater where it no longer is available to local native vegetation (Appleyard and Cook, 2008) to ameliorate the impacts of aluminium toxicity.

  International research has indicated that calcium depletion of sub-soils and shallow aquifer sediments has the potential to cause the progressive degradation of woodlands and dependent fauna (Schaberg *et al*., 2001). No monitoring data have been provided for calcium concentrations in deep groundwater to determine whether calcium depletion is taking place in the Cooljarloo area;

- The potential impacts on downgradient wetlands of elevated sulfate concentrations that are released into groundwater from the dredge pond and other parts of the Cooljarloo mine site have not been considered by SWC (2019). The discharge of high concentrations of sulfate-ions into seasonal groundwater-dependent wetlands can alter nutrient cycling within these features, leading to “internal eutrophication” (Smolders *et al*., 2006), degradation of vegetation communities and sulfide toxicity to some plant species and aquatic fauna (Geuerts *et al*., 2009). Further investigations would be required to quantify these risks at the Cooljarloo site and to develop site-specific trigger levels for sulfate concentrations in groundwater to protect sensitive environmental receptors that may be located downgradient of sulfate sources;

- DWER also supports the conclusion made by MWES (2015) that saline water detected in bores WMB07d, WMB12d and MSB10D is likely to be derived from seepage from the MRF. However, it is noted there are large gaps in the chemical analyses carried out in groundwater samples from these bores (as per the triennial aquifer review), therefore it is unclear whether groundwater near these bores contains concentrations of metals and metalloids at levels of environmental concern;

- There are currently insufficient monitoring bores in the vicinity of the MRF to define the extent of the saline groundwater plume that may be associated with historical waste disposal. The conclusion made by MWES (2015) that the contamination does not pose a risk to environmental receptors is considered to be premature;

- Insufficient information has been provided to determine whether low pH values detected in the dredge pond in 2014 were attributed to the disturbance of particularly sulfidic sediments at that time by mining activities, to the arrival of an acidic and saline groundwater plume at the pond at that time, or some other factor. The very large scatter of pH values measured in the dredge pond before 2014 suggests there are issues with how levels of acidity are measured within the pond. This could be improved by ensuring that Total Acidity and Total Alkalinity are measured in the field at the same time that pH measurements are made, as these parameters often give a more reliable indication of the overall acidity of a water body than pH measurements on their own;

- The range of analytes measured in groundwater samples is considered to be appropriate; however there are significant data gaps where specific analytes are not measured in a given bore for periods of several months. The issue of data consistency needs to be addressed; and

- Regarding the current management of clay fines, there is a risk that these tailings could acidify, potentially allowing metals to leach to groundwater or become bioavailable to plants, soil or fauna. It is therefore important the tailings consolidate as rapidly as possible in order to limit the risk of metals leaching into the environment.

**Key findings:**

1. It is likely that high groundwater salinity and acidity values measured in groundwater at the Premises have been caused by both mining activities and the effects of regional declines in the water table associated with low rainfall in the region.
2. An independent review of the current groundwater monitoring program is required to ensure it is fit-for-purpose. It is likely that additional bores will be required to monitor the ongoing expansion of the dredge pond along the orebody and to determine the full extent of the groundwater contamination plume associated with the MRF.

# 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 17.

The identification of the sources, pathways and receptors to determine risk events are set out in below.

**Table 17: 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 | Noise, dust | Billinue Aboriginal Community, Brand Hwy and Wongonderrah Rd | Air / wind dispersion | Amenity and/or human health impacts | No | Clearing of native vegetation is regulated through the State Agreement and relevant Ministerial Statements. |
| | Topsoil stripping, O/B removal and stockpiling | Acidified water / leachate from sulfide oxidation | Groundwater, groundwater dependent vegetation | Soil / groundwater | Groundwater contamination (acidification) | Yes | Refer to section 8.4 |
| | | Noise | Billinue Aboriginal Community, Brand Hwy and Wongonderrah Rd | Air / wind dispersion | Amenity impacts | No | Pre-mining works are typically short-term (campaign) in nature and there is sufficient separation in place between areas remaining to be mined and the nearest off-site receptor (> 5 km to the BAC).<br>No public complaints have been received by DWER regarding noise and fugitive dust from operations to date.<br>Any noise impacts that may occur from future pre-mining works can be regulated under the provisions of the Noise Regulations.<br>Any dust impacts that may occur from future pre-mining works can be regulated under the provisions of s.49 of the EP Act. |
| | | Fugitive emissions (dust) | | | Amenity and human health impacts | No | |
| **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<br>Operation of dredges and floating concentrator | Seepage / lateral infiltration | Groundwater | Dredge pond (as an expression of groundwater) | Groundwater mounding | No | Water levels within the dredge pond are artificially maintained at or below the natural water table by groundwater inflows, with losses through ore removal and evaporation supplemented by abstraction bores, return water and other recycled process water.<br>The risk of adverse impacts (groundwater mounding) is considered to be Low due to the large amounts of water consumed by mining operations. |
| | | | | | Groundwater contamination (acidification) | Yes | Refer to section 8.4. |
| | | Evaporation | | Air | Groundwater salinisation – concentration of salinity | Yes | Refer to section 8.5. |
| | | Hydrocarbon spills into the dredge pond | | Direct discharge | Groundwater contamination | No | There have been several incidents involving leaks and spills of hydraulic oil into the dredge pond over the years that have been generally minor in nature (<1,000 L) and the majority have been able to be recovered (skimmed or processed through the concentrator).<br>The risk of adverse impacts (groundwater contamination) is considered to be Low, based on implementation of licence holder control methods (including spill response) already in place. |
| | | Noise | Billinue Aboriginal Community, Brand Hwy and Wongonderrah Rd | Air / wind dispersion | Amenity impacts | No | There is sufficient separation in place between areas remaining to be mined and the nearest off-site receptor (> 5 km to the BAC).<br>No public complaints have been received by DWER regarding noise from 24/7 operations to date.<br>Any noise impacts that may occur from future mining and processing operations can be regulated under the provisions of the Noise Regulations. |
| | | Fugitive emissions (dust) | | | Amenity and human health impacts | No | The current mining method (wet dredge) typically generates low levels of dust due to the wet nature of the mining operation.<br>No public complaints have been received by DWER regarding fugitive dust from operations to date.<br>Any off-site dust impacts that may occur from future mining activities can be regulated under the provisions of s.49 of the EP Act. |
| | | | Vegetation adjacent to active mining areas | | Soil contamination, suppression of photosynthetic and respiratory functions of native vegetation, including several Rare and Priority flora species within the Premises boundary and immediate surrounds | No | |

| Risk Events | | | | | | Continue to detailed risk assessment | Reasoning |
|---|---|---|---|---|---|---|---|
| Sources/Activities | | Potential emissions | Potential receptors | Potential pathway | Potential adverse impacts | | |
| | Transfer of HMC from WCP to stockpiles | Rupture of pipeline causing HMC discharge to land or waters | Vegetation adjacent to pipelines | Direct discharge | Soil contamination, etc. (see above) | No | HMC pipelines are located within 10 m wide service corridors that are generally situated between a light vehicle road and a powerline corridor.<br>Industry standards controls are in place for preventing pipeline failure, in the form of real-time monitoring of pipeline pressures and flows. In the event of pipeline failure, these controls would ensure any spills are identified, and enable early management to ensure containment within the service corridor(s).<br>The risk of adverse impacts (soil contamination, etc.) is considered to be Low, based on implementation of licence holder controls already in place. |
| | Stockpiling of HMC | Seepage of water entrained in the HMC to groundwater | Groundwater, vegetation adjacent to stockpiles | Through base of HMC pad | Groundwater contamination | No | HMC stockpiles are constructed on compacted clay/gravel pads that are sloped to direct runoff to a collection sump. Collected water is recovered any pumped back to a mine void for reuse in the mining operation.<br>The risk of adverse impacts (groundwater contamination/ groundwater mounding/ vegetation impacts) is considered to be Low, based on implementation of licence holder controls already in place. |
| | | | | | Groundwater mounding | No | |
| | | Contaminated surface water runoff | | Direct discharge | Contamination of groundwater, soil, inhibiting vegetation growth and survival and health impacts to fauna | No | |
| | | Dust lift-off | Billinue Aboriginal Community, Brand Hwy and Wongonderrah Rd | Air / wind dispersion | Amenity and human health impacts | No | The risk of impacts from dust-lift off of HMC stockpiles is considered to be Low, given the location of HMC stockpiles relative to sensitive receptors, including native vegetation and other off-site receptors. |
| | | | Vegetation adjacent to stockpiles | | Soil contamination, etc. (see above) | No | |
| | Disposal of sand tailings (dredge pond) | Seepage of water entrained within the sand tailings to groundwater | Groundwater | Through base of the dredge pond | Groundwater contamination | No | Sand tailings (consisting principally of silica sand) returned to the dredge pond 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, washed beach sand).<br>The risk of adverse impacts (groundwater contamination) is considered to be Low, due to the absence of any significant leachable contaminants within the sand tailings. |
| | | | | | Groundwater mounding | No | Groundwater mounding from dredging operations has not been further risk assessed for the reasons stated above. |
| | Drying of clay fines | Seepage of water entrained in the clay fines to groundwater | | Through base of solar drying dam(s) | Groundwater contamination (acidification) | Yes | Refer to section 8.6. |
| | | | | | Groundwater mounding | No | Approximately half of the water entrained in the clay fines is recovered for reuse in the dredge pond, with the remainder either lost to evaporation or seepage to groundwater, once deposited into the solar drying dams.<br>Seepage from the clay fines has the potential to cause groundwater mounding, however there is a limit to the volume of water within the clay, the seepage rate is slow as the clay tends to retain moisture within it, and also acts as a natural lining system, once consolidated.<br>Groundwater levels within the vicinity of the solar drying dams are routinely monitored and show no signs of mounding.<br>The risk of mounding from clay fines is therefore considered to be Low. |
| | | Breach of containment causing fines discharge to land or waters | Mullering Brook and other ephemeral drainage lines | Direct discharge | Contamination of surface water, wetlands, soil, inhibiting vegetation growth and survival and health impacts to fauna | No | Solar drying ponds are constructed on-mine path or within existing mined out voids, and in proximity to the dredge pond, i.e. distant from sensitive environmental receptors.<br>The risk of impacts is considered to be Low based on the location of solar drying ponds. In the event of pond wall breaches the clay fines would be contained within the existing mining area. |
| | | Rupture of pipeline causing fines discharge to land or waters | Mullering Brook and other ephemeral drainage lines, ecosystems adjacent to pipeline alignment | | | No | Pipelines containing clay fines are predominantly located in proximity to the dredge pond, or within existing mining areas.<br>Industry standards controls are in place for preventing pipeline failure, in the form of real-time monitoring of pipeline pressures and flows. In the event of pipeline failure, these controls would ensure any spills are identified, and enable early management to ensure containment within the existing mining area.<br>The risk of adverse impacts (soil contamination, etc.) is considered to be Low, based on implementation of licence holder controls already in place. |
| | | Rupture of return water pipeline | | | | No | |

| Risk Events | | | | | | Continue to detailed risk assessment | Reasoning |
|---|---|---|---|---|---|---|---|
| Sources/Activities | | Potential emissions | Potential receptors | Potential pathway | Potential adverse impacts | | |
| | | Dust lift-off | Billinue Aboriginal Community, Brand Hwy and Wongonderrah Rd | Air / wind dispersion | Amenity and human health impacts | No | Solar drying dams are temporary in nature are constructed on-mine path or within existing mined out voids, i.e. in the middle of the Premises. They are either removed prior to mining or landformed to become part of the rehabilitated soil profile.<br>There is sufficient separation in place between solar drying dams and the nearest off-site receptor (> 5 km to the BAC).<br>The risk of adverse impacts (amenity/ human health impacts/ soil contamination, etc.) is therefore considered to be Low. |
| | | | Vegetation adjacent to solar drying ponds | | Soil contamination, etc. (see above) | No | |
| | Disposal of mineral processing residue into the Mineral Residue Facility (MRF) | Seepage of water entrained in the mineral processing residues | Bore users within proximity to the Premises<br>Groundwater , wetlands and associated water dependent ecosystems | Through base/wall of MRF cells | Groundwater contamination | Yes | Refer to section 8.7. |
| | | | | | Groundwater mounding | No | The mineral processing residue contains low moisture levels (2 – 25%) and is unlikely to generate significant volumes of leachate.<br>The risk of adverse impacts (groundwater mounding) is therefore considered to be Low. |
| | | Breach of containment causing residue discharge to land or waters | Mullering Brook<br>Groundwater , wetlands and associated water dependent ecosystems | Direct discharge | Contamination of surface water, groundwater, wetlands and associated water dependent ecosystems | Yes | Refer to section 8.8. |
| | | Dust lift-off | Billinue Aboriginal Community, Brand Hwy and Wongonderrah Rd | Air / wind dispersion | Amenity and human health impacts | No | There is sufficient separation in place between the MRF and the nearest off-site receptor (2.8 km to the BAC) and sensitive native vegetation.<br>Fugitive dust from the MRF is evident however appears to be contained within the Premises. Improvements are required with respect to this.<br>The risk of impacts is considered to be Low based on implementation of the licence holder's dust control measures, which includes:<br>- Sheeting waste pits with overburden to minimise the area of waste exposed at any point in time;<br>- Stabilisation of open areas with application of chemical stabilisers, clay slimes or planting crop covers;<br>- Active suppression of dust on working faces and haul roads by use of water trucks; and<br>- Dust deposition monitoring around the MRF, with an internal performance target. |
| | | | Vegetation adjacent to BWD, including rehabilitated mine areas | | Soil contamination, etc. (see above) | No | |
| | | Naturally Occurring Radioactive Material (NORM) | Groundwater | Through base of BWD cells | Groundwater contamination (mobilisation of radionuclides) | No | Radiological risks are regulated by DMIRS. |
| **Construction of MRF Cell 8** | Civil excavation/ earthworks/ cell construction works/ vehicle movements, etc. | Noise | Billinue Aboriginal Community, Brand Hwy and Wongonderrah Rd | Air / wind dispersion | Amenity and human health impacts | No | Some additional noise and dust is expected during construction works, however the levels are not expected to be significantly different from current noise and dust levels from existing operations at the Premises.<br>Based on the separation to off-site receptors (> 5 km to the BAC), the Delegated Officer does not reasonably foresee off-site receptors being impacted by noise and dust during construction works. |
| | | Fugitive emissions (dust) | | | | No | |

## 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 18 below.

**Table 18: 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 19 below.

**Table 19: Risk criteria table**

| Likelihood | |
|---|---|
| **The following criteria has been used to determine the likelihood of the Risk Event occurring.** | |
| Almost Certain | The risk event is expected to occur in most circumstances |
| Likely | The risk event will probably occur in most circumstances |
| Possible | The risk event could occur at some time |
| Unlikely | The risk event will probably not occur in most circumstances |
| Rare | The risk event may only occur in exceptional circumstances |

| Consequence | | |
|---|---|---|
| **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)** |
| Severe | • **onsite impacts**: catastrophic<br>• **offsite impacts local scale**: high level or above<br>• **offsite impacts wider scale**: mid-level or above<br>• Mid to long-term or permanent impact to an area of high conservation value or special significance^<br>• Specific Consequence Criteria (for environment) are significantly exceeded | • Loss of life<br>• **Adverse health effects:** high level or ongoing medical treatment<br>• Specific Consequence Criteria (for public health) are significantly exceeded<br>• **Local scale impacts:** permanent loss of amenity |
| Major | • **onsite impacts**: high level<br>• **offsite impacts local scale**: mid-level<br>• **offsite impacts wider scale**: low level<br>• Short-term impact to an area of high conservation value or special significance^<br>• Specific Consequence Criteria (for environment) are exceeded | • **Adverse health effects:** mid-level or frequent medical treatment<br>• Specific Consequence Criteria (for public health) are exceeded<br>• **Local scale impacts**: high level impact to amenity |
| Moderate | • **onsite impacts**: mid-level<br>• **offsite impacts local scale**: low level<br>• **offsite impacts wider scale**: minimal<br>• Specific Consequence Criteria (for environment) are at risk of not being met | • **Adverse health effects:** low level or occasional medical treatment<br>• Specific Consequence Criteria (for public health) are at risk of not being met<br>• **Local scale impacts:** mid-level impact to amenity |
| Minor | • **onsite impacts**: low level<br>• **offsite impacts local scale**: minimal<br>• **offsite impacts wider scale**: not detectable<br>• Specific Consequence Criteria (for environment) likely to be met | • Specific Consequence Criteria (for public health) are likely to be met<br>• **Local scale impacts:** low level impact to amenity |
| Slight | • **onsite impact**: minimal<br>• Specific Consequence Criteria (for environment) met | • **Local scale**: minimal to amenity<br>• 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 table below:

**Table 20: 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.<br>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 – Sulfide oxidation (Acid Sulfate Soils)

### 8.4.1 Description of risk event

Acidification of groundwater generated from oxidation of aquifer materials containing sulfides and/or oxide-hydroxides of iron, leading to degradation of water quality and environmental values through dispersion and groundwater migration.

### 8.4.2 Identification and general characterisation of emission

The licence holder has conducted pre-mine screening for ASS since 2010 as part of ongoing exploration and resource drilling. Screening results collected to date indicate that sulfidic minerals generally occur ubiquitously throughout the in-situ soil profile across the Premises, albeit at levels below the current DWER trigger level (0.03% S). Although this is the case, the predominantly sandy (quartz) materials mined have limited inherent buffering capacity, and thus oxidation of these sulfides has generally caused acidification to occur.

Whilst the quantity of acidity released from these 'trace' sulfides is considered small, the concentration and partial oxidation of these sulfides during mineral processing has become problematic (refer to section 7.1), and represents significant challenges to neutralisation and to prevent environmental/rehabilitation impact.

### 8.4.3 Description of potential adverse impact from the emission

Wherever significant groundwater acidification has occurred, groundwater will contain elevated concentrations of some metals (particularly aluminum) and sulfate, often at levels that could cause adverse impacts on phreatophytic vegetation and groundwater dependent wetlands in the area (Geurts *et al*., 2009). Acidic groundwater conditions also increase the risk that radium will be released into groundwater from the leaching of monazite and desorption from clay minerals in the aquifer sediments (USGS, 2012).

### 8.4.4 Criteria for assessment

The DWER guideline *Identification and investigation of acid sulfate soils and acidic landscapes* (DER, 2015a) 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 (e.g. DMIRS).

As discussed in section 7.1, there are significant and ongoing acidity issues being observed in the dredge pond. Based on available scientific literature, DWER considers the pH of the dredge pond should be maintained above 6.0 to minimise the risk of some metals leaching from solution e.g. aluminium, zinc and cadmium.

### 8.4.5 Licence holder controls

The Cooljarloo EMP provides a framework for the identification and management of potential ASS (PASS) through a risk assessment that includes pre-mining screening (sampling and analysis of areas of potential risk, such as material below the water table [perched or superficial aquifer]) to identify areas of PASS, and the development of area specific management plans where appreciable sulfidic materials are identified.

An ASS management plan (ASSMP) is in place for the dredge operations (i.e. South Mine) that includes a site conceptual model for the GR6 and Site 12 orebodies, based on results obtained from pre-mining screening and ASS investigations (SWC, 2015). Management and contingency strategies outlined in DWER guidelines[7] have been considered on the basis of the conceptual model, and summarised Table 21.

**Table 21: Licence holder controls for Acid Sulfate Soils**

| Aspect | Control |
|---|---|
| Risk assessment | ASS soil field screening is conducted within the resource boundary and area of groundwater drawdown to assess if potentially acid forming materials are present |
| Management | Area specific management plans are developed for those areas where the disturbance of ASS could potentially impact sensitive environmental receptors |
| | Performance against site specific management plans and related monitoring programs are regularly reviewed and reported |
| Monitoring | Active mining pit in areas of ASS risk – as required in areas of risk<br>Parameters: characteristics of lithology, field pH ($pH_F$) and field pH peroxide ($pH_{FOX}$) |
| | Groundwater quality (in pit and surrounds of ASS risk vicinity); Monthly basis<br>Parameters: pH, alkalinity, electrical conductivity, aluminium, iron, sulfate: chloride ratio |
| | Tailings waste: soil and water quality at tailings discharge points; Weekly during mining of pits with identified areas of risk<br>Parameters: Field screening using $pH_{FOX}$ in high risk areas (incl. laboratory analysis as required) |
| Contingencies | Water quality above internal targets:<br>1. Investigate the cause/significance of the issue and raise an incident report |

[7] *Identification and investigation of acid sulfate souls and acidic landscapes* (DER, 2015a); *Treatment and management of soils and water in acid sulfate soil landscapes* (DER, 2015b).

| Aspect | Control |
|---|---|
| | if deemed necessary;<br>2. Review operational management measures, escalate control where possible and necessary;<br>3. Review systems and implement corrective actions to minimise the risk of reoccurrence;<br>4. Determine if remediation is required to maintain ecological values;<br>5. Develop and implement a remediation plan if necessary and consult the relevant government regulator as required;<br>6. Monitor outcomes |
| | Field screening results are above the threshold criteria for $pH_{FOX}$ or $S_{CR}$:<br>1. Incorporate field screening results into the site conceptual model and assess the risk to sensitive environmental receptors;<br>2. Develop a management response with consideration to internal procedures and DWER guidelines (where risk determines) |

Following a targeted investigation to determine the key driver causing the observed acidity within the dredge pond and the lack of buffering response following the addition of a considerable quantity of neutralising agent (refer to section 7.1.2), additional management strategies have been developed for the dredge operations, and summarised in Table 22.

**Table 22: Licence holder controls for the dredge operations**

| Aspect | Control |
|---|---|
| Drilling | Testing 1 in every 15 drill holes (>0.2 holes/ha) for $pH_F$ and $pH_{FOX}$ during all mine drilling |
| | Conduct ASS analysis in accordance with internal operational procedure based on DWER guidelines[8] during all mine drilling |
| | >3 months prior to excavation of overburden and mining of ore in each mining block, distribute a 3D plan showing the spatial extent and % of reactive material per mining block to be removed<br>All samples $pH_{FOX}$ >2 or $S_{cr}$ >0.03 % are to be considered acidic |
| Overburden | >3 months prior to excavation of overburden, develop material movement plan. Reactive materials to be treated and buried at depth as soon as possible |
| | Conduct daily field surveys during removal of overburden containing PASS (or in areas where there are indicators of PASS) to identify reactive areas outside of those mapped |
| | Reactive material to be dumped as per material movement plan and disposal locations recorded |
| | Treat reactive material with lime once dumped at an indicative rate of 5 kg/t ($CaCO_3$) and buried >10 m from surface |
| | Reactive overburden/oversize that is to be stockpiled prior to burial shall be on a lime pad to mitigate seepage |
| Oversize in ore | Deposited at the base of the dredge pond |
| Clay fines | Maintain the overall volume of clay fines in the dredge pond to a practical minimum |
| | Where pH in the dredge pond falls below 4.5, undertake active management to raise above 5.0 |

[8] *Identification and investigation of acid sulfate souls and acidic landscapes* (DER, 2015a); *Treatment and management of soils and water in acid sulfate soil landscapes* (DER, 2015b).

| Aspect | Control |
| --- | --- |
| | Monitor TAA and Total Potential Acidity (TPA) in the clay fines at least fortnightly to determine if ongoing management is required |
| | Determine TAA and TPA of the dried clay fines in solar drying dams, dewatering dams and other voids, prior to landforming |
| | Where TAA and TPA exceed 18 mol H+/t undertake active management to treat the material or bury at depth (> 5 m below surface)<br>Lime required determined by kg $CaCO_3$/t = Net Acidity (mol H+/t) x 0.05 |
| Sand tailings | Monitor TAA and TPA on a monthly basis to determine if ongoing management is required |
| | Where TAA and TPA exceed 18 mol H+/t undertake active management to treat the material or bury at depth (> 5 m below surface)<br>Lime required determined by kg $CaCO_3$/t = Net Acidity (mol H+/t) x 0.05 |
| Groundwater monitoring | Conduct water sampling and review as per Operating Strategy• |
| | Review water quality results monthly and investigate those outside of baseline levels |
| | Monitor dredge pond pH at least weekly and connected voids at least fortnightly |

### 8.4.6 Key findings

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

1. From the available information, there appears to be significant quantities of PASS present at the Premises.
2. Sulfide oxidation is clearly taking place at the Premises and there is likely to be increasing concentrations of iron, aluminium and zinc in groundwater in the affected areas.
3. Despite the low amount of acidity in the soils there is no buffering capacity – enough acidity is being produced to leach significant concentrations of metals from soil materials into infiltrating water.
4. There is a potential risk that radium could be leached from the fines into groundwater under the current acidic conditions (i.e. pH < 6). This risk is somewhat being addressed through transferring the fines from the dredge pond to external ponds, however additional actions are required to increase and maintain the pH of the dredge pond above 6.0.
5. The amount of residual clay fines within the dredge pond represents a significant challenge to neutralisation and to prevent environmental/rehabilitation impact.

### 8.4.7 Consequence

Mining activities to date have caused increases in groundwater acidity which in turn has led to increases in metals and sulfate concentrations in groundwater to levels that could cause adverse impacts on the health of phreatophytic vegetation and of wetlands that receive groundwater discharge in the area.

The Delegated Officer therefore considers the consequence of sulfide oxidation to be **Major**.

### 8.4.8 Likelihood of Risk Event

It is **Likely** that groundwater quality in the region will continue to deteriorate over a larger area with the continuation of mining at the site.

### 8.4.9 Overall rating of sulfide oxidation

The Delegated Officer has compared the consequence and likelihood ratings described above with the risk rating matrix (Table 20) and determined that the overall rating for the risk of sulfide oxidation is **High**.

## 8.5 Risk Assessment – Groundwater salinisation

### 8.5.1 Description of risk event

Groundwater salinisation (secondary salinity) caused by evaporation from the surface of the dredge pond and the flushing of dissolved salts from upgradient sources (including naturally occurring and those generated from historical dewatering), leading to the development of saline groundwater plume(s) and potential impacts to environmental values.

### 8.5.2 Identification and general characterisation of emission

Evaporation from the dredge pond represents a significant loss of water – up to 1 GL/a – from the mine site (HGEO, 2018). Water levels in the dredge pond are maintained by rainfall and production water, however due to the depth of the pond (up to 25 m) the mixing of water is likely to be occurring only within the upper layers, and high salinity water may be present at specific depth intervals of the pond.

The distribution of salinity in groundwater near the dredge pond has been made more complex due to upgradient sources of dissolved salts (including historical dewatering) that are likely to have influenced the distribution of saline groundwater in the area. Salinity levels within the dredge pond itself are likely to be exacerbated from sulfide oxidation caused by mining activities.

The magnitude of the salinity detected in bores downgradient of the dredge pond will depend on their screened intervals and whether they are constructed within the core of the plume.

### 8.5.3 Description of potential adverse impact from the emission

Background groundwater quality at the Premises is considered to be of generally good quality; therefore the development and migration of saline groundwater plumes are likely to have implications on environmental values of the groundwater resource.

According to NHMRC & NRMMC (2011), it is difficult to remove dissolved solids from water. Current technologies include reverse osmosis, ion exchange and distillation, however all these require considerable energy input and can be expensive to operate. In addition, these processes generate hypersaline brine residues that require disposal (without causing additional contamination issues).

Salinity often determines the possible uses of groundwater. As discussed in section 4.1.6, the use of shallow groundwater for potable purposes at the site is currently undetermined, but may be a possibility at the conclusion of mining. However, there is the potential for saline groundwater to migrate outside of the mine disturbance footprint and impact on the health of phreatophytic vegetation and wetlands that receive groundwater discharge in the area.

### 8.5.4 Criteria for assessment

Where background water quality indicates there is potential for groundwater to be used for as a drinking water resource (even where it is not currently being used for that purpose), the Australian Drinking Water Guidelines (ADWG) (NHMRC & NRMMC, 2011) are the most appropriate assessment criteria to apply to ensure the groundwater resource is protected for future use (DER, 2014).

The guideline levels for total dissolved solids in drinking water are based on quality (taste), not safety (health risk) and should not exceed 500 mg/L, although water with levels up to 1,000 mg/L are acceptable to many. Levels exceeding 1,200 mg/L are regarded as "unacceptable".

### 8.5.5 Licence holder controls

The issue of groundwater salinisation caused by mining activities is not specifically addressed within the EMP.

### 8.5.6 Key findings

**The Delegated Officer has reviewed the information regarding the risk of groundwater salinisation and has found:**

1. Mining activities are likely to be increasing groundwater salinities at the site. Evaporation from the pond's surface is likely to be sufficient to concentrate levels of dissolved salts and generate saline groundwater plumes. The significant size of the pond (currently 77 ha) is likely to be exacerbating this issue.
2. Current treatment options for saline groundwater require considerable energy input and can be expensive to operate. It is therefore imperative that good quality groundwater resources are protected from activities that may increase salinity levels.

### 8.5.7 Consequence

Mining activities to date have contributed to increases in groundwater salinity that exceed levels regarded as unacceptable according to the ADWG. In addition, elevated groundwater salinities may cause adverse impacts on the health of phreatophytic vegetation and of wetlands that receive groundwater discharge in the area.

The Delegated Officer therefore considers the consequence of groundwater salinisation to be **Major**.

### 8.5.8 Likelihood of Risk Event

It is **Likely** that groundwater quality in the region will continue to deteriorate over a larger area with the continuation of mining at the site.

### 8.5.9 Overall rating of groundwater salinisation

The Delegated Officer has compared the consequence and likelihood ratings described above with the risk rating matrix (Table 20) and determined that the overall rating for the risk of groundwater salinisation is **High**.

## 8.6 Risk Assessment – Seepage of clay fines

### 8.6.1 Description of risk event

Acidification of groundwater beneath solar drying dams or equivalent, generated from oxidation of pyrite contained within clay fines, leading to degradation of water quality and environmental values through dispersion and groundwater migration.

### 8.6.2 Identification and general characterisation of emission

As discussed in section 7.1.2, clay fines removed from the dredge pond and placed in solar drying dams will be acidic and likely to contain sufficient residual sulfides (i.e. PASS) to cause the pH of the material to drop to around 2.5 if allowed to fully oxidise.

### 8.6.3 Description of potential adverse impact from the emission

The adverse properties of the clay fines will limit the handling and utilisation of the material in rehabilitation.

If the material is buried at shallow depth in the soil profile beneath land that will be used for agriculture, there is an increased risk that nitrate from fertiliser use and stock wastes will cause the pyrite that is entrained within the clays to oxidise, releasing metals and sulfate. Work conducted by the U.S. Geological Survey (USGS, 1998) has shown there is a strong relationship between nitrate and U and Ra concentrations in shallow aquifers in the United States, where nitrate application in fertilisers can lead to pyrite oxidation (even in the absence of oxygen) where U and Ra release under reduced pH and increased oxidising conditions.

### 8.6.4 Licence holder controls

According to the ASSMP (Tronox, 2017), all fines generated in the 'south' mine will be considered as both AASS and PASS when planning on how and where to use this material.

Clay fines will be treated with Ag lime at a rate commensurate with the materials reactivity, if it will be deposited within 1.5 m of the final surface, however no lime dosing will occur where the material is to be disposed at the base of a mined void.

### 8.6.5 Key findings

**The Delegated Officer has reviewed the information regarding the risk of seepage from clay fines and has found:**

1. The management of clay fines by discharge to external solar drying dams is considered to be acceptable, provided these materials are treated with an appropriate reagent to accelerate their flocculation and consolidation to limit the risk of pyrite oxidation and the leaching of metals into the environment.

### 8.6.6 Consequence

Increases in groundwater acidity can lead to increases in metals and sulfate concentrations in groundwater to levels that could cause adverse impacts on the health of phreatophytic vegetation and of wetlands that receive groundwater discharge in the area.

The Delegated Officer therefore considers the consequence of seepage from clay fines to be **Major**.

### 8.6.7 Likelihood of Risk Event

It is considered **Unlikely** that significant acidity would be generated from oxidation of pyrite contained within clay fines if the material is treated with an appropriate reagent to accelerate their flocculation and consolidation.

### 8.6.8 Overall rating of seepage from clay fines

The Delegated Officer has compared the consequence and likelihood ratings described above with the risk rating matrix (Table 20) and determined that the overall rating for the risk of seepage from clay fines is **Medium**.

## 8.7 Risk Assessment – Leaching of mineral processing residues

### 8.7.1 Description of risk event

Leachate from the MRF cells, reaching the water table and moving westwards in response to groundwater flow, causing impacts to groundwater, off-site groundwater users and/or ecological receptors.

### 8.7.2 Identification and general characterisation of emission

The mineral processing residue stream comprises iron oxide solids, filter cakes from the various chemical processes and reject sand tailings. It contains a variety of metals, soluble salts (principally sulfate and chloride) and low levels of radionuclides. As discussed in section 4.1.6, leach testing of these waste streams indicates that average concentrations of several heavy metals are well in excess of the EILs listed in the guidelines for assessing and managing contaminated sites (DEC, 2010), particularly chromium. It is noted however, the ASLP leach testing methodology is considered outdated, and that the preferred leaching tests are the USEPA LEAF tests (or equivalent European Union suite of leaching tests).

Studies have indicated there is potential for heavy metals to be mobilised in leachate, and for salinity to be generated in leachate (HGM, 1996; PPK, 2001b). DWER's experience in relation to historical disposal of filter cakes from the synthetic rutile process in a poorly lined facility at

Capel has demonstrated that residues from the production of synthetic rutile has the potential to release significant concentrations of sulfate, iron and manganese to groundwater.

A review of dissolved metal concentrations in the 'WMB' series of bores over the entire monitoring record shows no significant trends, however as discussed in section 0, the distribution of these bores does not provide a clear understanding on groundwater impacts caused by the MRF pits.

As discussed in section 7.2.3, rising groundwater salinities have been observed over several decades in one of the closest observation bores located east of the MRF. Although no direct evidence can be found from the available information into the cause of the elevated salinities (up to 15,000 µS/cm) observed in bore MSB10D, it is considered likely that a saline groundwater plume has migrated from a rehabilitated MRF pit used in 1993. This is likely to be indicative of a larger issue.

### 8.7.3 Description of potential adverse impact from the emission

Leachate from mineral processing residue has the potential to affect groundwater quality and other environmental values.

As discussed in section 4.1.6, groundwater, wetlands and water dependent ecosystems have been identified as the most sensitive ecological receptors, particularly Mullering Brook and its associated wetlands to the west of the MRF. Elevated groundwater salinities and increased heavy metal concentrations can produce large changes in ecology that may rely on freshwater environments.

High groundwater salinity and/or heavy metal concentrations are likely to impact on the environmental values, or uses, of the groundwater resource, such as ecosystem maintenance, or future potable water supply, irrigation or stock watering purposes.

### 8.7.4 Criteria for assessment

As discussed in section 8.5.4, where background water quality indicates there is potential for groundwater to be used for as a drinking water resource (even where it is not currently being used for that purpose), the ADWG (NHMRC & NRMMC, 2011) are the most appropriate assessment criteria to apply to ensure the groundwater resource is protected for future use (DEC, 2010).

The Delegated Officer is also cognisant of the CS Act provisions, where the threshold for 'contamination' of groundwater is relatively low, and that actions may be required to address levels that are considerably above natural background quality.

### 8.7.5 Licence holder controls

As discussed in section 4.1.6, the licence holder has implemented a number of recommendations made by PPK (2001) following an assessment of the risks to receptors from the earlier unlined (or partially-lined) black waste pits. In practice, this involves conformance to the Water Quality Protection Guidelines for Mining and Mineral Processing (WRC, 2000), which requires pits to be constructed with an engineered clay lining (Table 23).

**Table 23: Licence holder controls for leaching to groundwater from the MRF**

| Control | Description |
| --- | --- |
| Pit design | • Construction of engineered cells on top of old mine tailings, to achieve minimum 3 m separation to highest seasonal water table levels;<br>• Lining of pit floor with 300 mm clay liner, placed in two 150 mm layers and compacted/rolled to >95% of Maximum Dry Density;<br>• Grading of the floor towards an overflow drain, to allow for the removal of rain fall or seepage during filling;<br>• Final capping of >2 m, including 300 mm compacted overburden, below 2 m of sand tailings and overburden and topsoil layer. |

| | |
|---|---|
| Waste analysis | • Quarterly leach testing of blended waste residues; |
| Monitoring | • Groundwater quality monitoring through existing bore network to identify any potential lining failure;<br>• Visual site inspections to identify visible signs of potential problems and consequent investigations to confirm actual liner failure. |

### 8.7.6 Key findings

**The Delegated Officer has reviewed the information regarding the risk of leaching of mineral processing residues and has found:**

1. There is potential for heavy metals to be mobilised in leachate and for salinity to be generated in leachate.
2. There is a need for leachate testing of the waste materials under the USEPA's Leaching Environmental Assessment Framework (LEAF).
3. The natural soil profile beneath the MRF has been subject to high levels of disturbance, and the hydrogeological setting may be complicated by the presence of local zones of either low or high permeability. Further detailed information is therefore required to characterise the local hydrogeological setting, and to adequately assess potential pathways for leachate transport.
4. The current WMB series of monitoring bores does not provide a clear understanding on groundwater impacts caused by the black waste pits. In addition, there are large gaps in the chemical analyses carried out in groundwater samples from these bores – it is therefore unclear whether groundwater near these bores contains concentrations of metals and metalloids at levels of environmental concern.
5. Further investigations are required into the significant groundwater salinities being observed in bore MSB10D.

### 8.7.7 Consequence

The potential release of sulfate, iron and manganese to groundwater presents a moderate level of permanent on-site impacts, and potential for off-site impacts at a local scale. As can be seen at the former-South Capel mine site, the leaching of residues from unlined cells has resulted in significant contamination of the groundwater resource, and presents a high risk to achieving site closure aims.

The Delegated Officer therefore considers the consequence of the leaching of mineral processing residues to be **Moderate**.

### 8.7.8 Likelihood of Risk Event

It is likely that localised contamination of shallow groundwater in proximity to the MRF is occurring, particularly from the earlier unlined or partially lined waste pits. It is also considered **Likely** that the quality of shallow groundwater will continue to deteriorate over a larger area with the continuation of waste disposal at the site.

### 8.7.9 Overall rating of leaching of black waste residues

The Delegated Officer has compared the consequence and likelihood ratings described above with the risk rating matrix (Table 20) and determined that the overall rating for the risk of leaching of mineral processing residues is **High**.

## 8.8 Risk Assessment – Contaminated surface water runoff (MRF)

### 8.8.1 Description of risk event

Surface water runoff from the Mineral Residue Facility, contaminated with mineral processing residues and its leachate, entering Mullering Brook or nearby wetlands.

### 8.8.2 Identification and general characterisation of emission

Surface water runoff from the MRF is likely to be contaminated with mineral processing residues and its leachate. The general characterisation of the mineral processing residue and its leachate is included in section 8.7.2 above.

### 8.8.3 Description of potential adverse impact from the emission

Surface water contaminated with mineral processing residue and its leachate has the potential to affect the ecology and functioning of Mullering Brook and its associated wetlands, groundwater quality and other environmental values.

### 8.8.4 Licence holder controls

Runoff is directed to a perimeter 'drain' that runs adjacent to the lowest edge of the pit (Figure 13). The drain is located approximately 100 m from Mullering Brook and comprises a bunded wall constructed with overburden to contain any water. The floor of the drain forms part of the MRF cell, which is clay lined. A drain is located at the lowest point of the cell where water can overflow externally from the MRF.

***Figure 13: Seepage and surface water runoff from the MRF is contained within the perimeter embankment area.***

### 8.8.5 Key findings

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

1. Containment of surface water runoff and seepage from the MRF appears to be insufficient from the available information.
2. The design of the surface water containment area, and the water holding capability of the bunded wall, is unclear.
3. There is concern the design of Waste Pit 7 includes a drain at the lowest point that would potentially allow water contaminated with mineral processing residue or its leachate to discharge to the environment.

### 8.8.6 Consequence

The release of surface water runoff contaminated with mineral processing residue or its leachate, either through the bunded wall or overflow from the containment area, presents a moderate level of impacts to sensitive nearby receptors, such as Mullering Brook and its associated wetlands.

The Delegated Officer therefore considers the consequence of the leaching of mineral processing residue to be **Moderate**.

### 8.8.7 Likelihood of Risk Event

It is considered **Unlikely** that impacts would occur in most circumstances, however in the absence of additional information on the management of surface water around the MRF, including design details of the containment system, it is **Possible** the design of the containment system is insufficient to prevent impacts from occurring during high rainfall events.

### 8.8.8 Overall rating of contaminated surface water runoff from the MRF

The Delegated Officer has compared the consequence and likelihood ratings described above with the risk rating matrix (Table 20) and determined that the overall rating for the risk of contaminated surface water runoff from the MRF is **Medium**.

## 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 24 below. Controls are described further in section 9.

**Table 24: Risk assessment summary**

| | Description of Risk Event | | | Applicant controls | Risk rating | Acceptability with controls (conditions on instrument) | Resulting regulatory controls |
|---|---|---|---|---|---|---|---|
| | **Emission** | **Source** | **Pathway/ Receptor (Impact)** | | | | |
| 1. | Acid Sulfate Soils | In situ soils with sulfide minerals | Groundwater contamination (acidification) | Pre-mine screening<br>Site specific ASS management plans<br>Field screening<br>Continuous lime dosing of the dredge pond<br>Desliming the dredge pond – clay fines pumped to solar drying dams | **High Risk**<br>Major consequence<br>Likely likelihood | **Unacceptable**<br>ASS has been poorly managed at the site and current attempts to maintain dredge pond pH above 6.0 appear inadequate and are likely to be unsustainable<br>ASS issues are likely to continue over a larger area with the continuation of dredge mining at the site | Licence to specify:<br>- Remedial actions to ensure water quality within the dredge pond is maintained above pH 4.5 with average monthly pH ≥ 5.0 (monthly values to be based on fortnightly measurements)<br>- Monitoring of the entire dredge pond to demonstrate the variation both horizontally and vertically across the pond<br>- Controls during pre-mine drilling and for management of overburden and clay fines<br>- Investigation into leakage rates from the pond into groundwater to estimate long-term impacts of seepage from the dredge pond |
| 2. | Groundwater salinisation and metalliferous drainage | Dredge pond | Groundwater contamination | Monitoring of groundwater quality and native vegetation | **High Risk**<br>Major consequence<br>Possible likelihood | **Unacceptable**<br>Groundwater salinity in and around the dredge pond has steadily increased to unacceptable levels and is likely to deteriorate over a larger area with the continuation of dredge | No licence controls, pending results of the investigation into leakage rates from the pond into groundwater (see above) |

| | Description of Risk Event | | | Applicant controls | Risk rating | Acceptability with controls (conditions on instrument) | Resulting regulatory controls |
|---|---|---|---|---|---|---|---|
| | **Emission** | **Source** | **Pathway/ Receptor (Impact)** | | | | |
| | | | | | | mining at the site | |
| 3. | Tailings – clay fines component | Dredging process | Groundwater contamination (leaching of metals) | Treated with lime if to be disposed within 5 m of the final land surface<br>No treatment if disposed at the base of mined voids | **Moderate Risk**<br>Moderate consequence<br>Possible likelihood | Acceptable subject to regulatory controls conditioned | Licence to specify:<br>- Overall amount of clay fines within dredge pond to be kept to a minimum<br>- Management specified for AASS and PASS, in terms of disposal and treatment |
| 4. | Mineral processing residue leachate (seepage) | Mineral Residue Facility | Groundwater contamination (leaching of metals and salinity, causing off-site impacts) | Disposal in engineered pits with compacted clay liners<br>Minimum 3 m separation to groundwater<br>Capping of pits upon closure | **High Risk**<br>Moderate consequence<br>Likely likelihood | **Unable to be determined** – further information required | Licence to specify:<br>- Authorised waste types and handling;<br>- Ongoing groundwater monitoring for full metals suite<br>- Construction requirements for Cell 8, including construction and quality assurance, certification and reporting |
| 5. | Contaminated surface water (MRF leachate) | | Surface flow to Mullering Brook, adjacent wetlands, groundwater | 1 km long bund constructed around the lower edge of the MRF, designed to contain surface water runoff and seepage | **Medium Risk** | Acceptable subject to licence holder controls and additional regulatory controls conditioned | Licence to specify:<br>- Surface water runoff from the MRF must be contained within the perimeter embankment of the MRF;<br>- Provision for overflow into a lined containment sump<br>- Surface water runoff or MRF leachate must not be discharged or allow to overflow into Mullering Brook or the dredge pond |

# 9. Regulatory controls

A summary of regulatory controls determined to be appropriate for the Risk Event is set out in Table 24. The risks are set out in the assessment in section 8 and the controls are detailed in this section. DWER has determined controls having regard to the adequacy of existing licence holder controls. The conditions of the revised licence have been set to give effect to the determined regulatory controls.

## 9.1 Licence controls

### 9.1.1 Authorised emissions

A requirement has been imposed (revised licence condition 1) to specify the authorised location(s) for disposal of mine tailings (waste sand and clay) and mineral processing residues during mining operations.

***Note:*** *The requirements specified in Table 1 of the revised licence generally replicate the requirements of the Mine Closure Plan for the Premises.*

***Grounds:*** *DWER's risk assessment is based on the disposal of mine tailings and mineral processing residues in the locations specified in the Mine Closure Plan. 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 – MRF Extension (Cell 8)

An extension of the MRF (Cell 8) is authorised for construction as per the design and construction requirements outlined in the below table (revised licence conditions 2, 3 & 4).

| Infrastructure | Requirements (design and construction) |
|---|---|
| Base (floor) liner | (i) Must be constructed in accordance with engineering design drawings shown in Figures 3 & 4 of Schedule 2 of this licence;<br>(ii) Surface level must be at least 3 m above the highest seasonal water table;<br>(iii) Cell liner must be keyed into the existing Pit 7 Ext 1&2 floor lining;<br>(iv) Cell floor must be graded towards the lowest point;<br>(v) Cell liner must comprise a minimum 300 mm clay overburden or slimes meeting the following properties:<br>(a) clay (DDR of >95%) soil with a permeability of at least $1x10^{-9}$ m/s;<br>(b) percentage of fines passing 75-micron sieve: greater than 25%;<br>(c) liquid limit: less than 70;<br>(d) plasticity index: greater than 15; and<br>(e) Emerson class number: 5 to 6;<br>(vi) Cell liner must be placed in two layers (minimum 150 mm each layer), compacted and rolled over the entire cell floor and wall embankments to a minimum of 95% Standard MDD in accordance with AS 1289.5.1.1;<br>(vii) All earthworks must be inspected, approved and reported in accordance with Level 1 Inspection and Geotechnical Testing, as per AS 3798;<br>(viii) Construction quality assurance of the constructed liner must be completed for:<br>(a) Level 1 Inspection and Geotechnical Testing, as per AS 3798-2007; and<br>(b) Compliance with the specifications for cell liner material, compaction and density listed above; |
| Outer embankments | (i) Maximum crest level ≤ 3.0 metres (above the lined floor);<br>(ii) Maximum slope angle 1:14 (V:H) in a northwesterly direction and 30° at the southern side;<br>(iii) Must be lined and compacted to the same specifications as the floor liner; |

| Infrastructure | Requirements (design and construction) |
|---|---|
| | (iv) Width along the top of each embankment must be at least 6.0 m wide; |
| Emergency spillway | (i) Must be installed at least 0.3 m below the embankment crest at the lowest point. |

***Note:*** *The requirements specified in the above table (Table 2 of the revised licence) generally reference the design and specifications outlined the MRF application and are consistent with the requirements as per the Water Quality Protection Guidelines No.3 - Mining and Mineral Processing - Liners for waste containment (Water and Rivers Commission, 2000).*

*Additional design and construction requirements have been determined as being necessary to mitigate known and potential risks identified in this decision report, including appropriate construction and quality assurance processes.*

***Grounds:*** *The construction of MRF Cell 8 is considered a significant extension to the existing facility, providing for an estimated 20 year lifespan. DWER therefore needs to ensure the facility has been constructed to relevant standards and, in the absence of approvals required under the Mining Act, that the facility will remain a safe, stable landform that manages safety and environmental risks.*

*Due to the nature of the residues being deposited, proximity to the water table and the facility being constructed over a previously mined (i.e. disturbed) profile, the integrity of the base liner system is of fundamental importance. In order to provide confidence to government, industry, professional and community stakeholders, construction of this component must be inspected, approved and reported in accordance with relevant construction and quality assurance processes, which in the case of natural clay liners is Australian Standard AS 3798-2007.*

*Upon completion of the works, submission of a Construction Compliance and Quality Assurance Validation Report is required. This report must be prepared by a licensed professional engineer, and must include details of all testing undertaken, including certification the works comply with the requirements of the specifications and drawings, in order to demonstrate the works have been appropriately constructed, prior to the deposition of waste residues.* ***A subsequent licence amendment will be required to authorise the deposition of waste residues in the constructed cell.***

### 9.1.3 Construction works – other

The following infrastructure is authorised for construction as per the design and construction requirements outlined in the below table (revised licence conditions 5 & 6).

| Infrastructure | Requirements (design and construction) |
|---|---|
| Solar drying dams | • Must be constructed within previous mine voids or on-mine-path;<br>• Dam floors must be constructed with a minimum slope of 1:300;<br>• Embankment walls mustt be constructed with compacted overburden or clayey sand (containing a fines content of < 30%) with angle of repose for the outer pond wall being at least 1:3 (V:H);<br>• Embankment wall height must not to exceed 5 metres. |

***Note:*** *The requirements specified in the above table (Table 3 of the revised licence) generally replicate the design and specifications outlined in the licence holder's internal operating manual for Tailings Storage Facilities (C0348), and have been determined as being required to mitigate potential risks identified in this decision report.*

***Grounds:*** *DWER acknowledges the progressive nature of mineral sands mining and the need to 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 revised licence provides an ongoing* *authorisation for construction, providing the construction is in accordance with specified design criteria.*

*In addition, the DWER considers that actual or potential impacts from the drying of clay fines should be limited to current or future disturbed areas, and therefore solar drying dams are no longer to be constructed external to disturbed areas.*

### 9.1.4 Specified infrastructure and equipment

The following environmental controls, infrastructure and equipment should be maintained and operated to manage the risk of impacts to environmental receptors (revised licence conditions 7, 8 & 9):

- Design capacity of all mining and processing infrastructure to be specified;
- Hydrocarbon spills kits must be located on each dredge at all times (whilst operating);
- HMC stockpile pad to be designed to drain surface water runoff to a collection sump via a sediment control structure;
- Operational freeboard of 0.5 m vertical distance on solar drying dams 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;
- 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; and
- Surface water runoff and leachate from the MRF is to be contained within the MRF perimeter embankment area.

***Note:*** *The requirements specified above generally replicate existing licence holder 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 known and potential risks identified in this decision report.*

***Grounds:*** *All major mining infrastructure and their current design capacities have been specified in the revised 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 dams, 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 licence holder controls around surface water runoff from the HMC stockpile. Given the quality of water contained within the HMC that is allowed to drain from the stockpile (i.e. potentially low pH, high salinity), DWER considers that controls are warranted in order to minimise the potential risk of overtopping and/or infiltration of this water, and has therefore specified the minimum design specifications for the pad and collection sump commensurate to this risk.*

*A review of the most recent above ground MRF cells that have been constructed over previously dredged areas has identified the cells have been designed with a perimeter embankment to contain surface water runoff and potential leachate. This area is designed with sufficient capacity to contain a 1% AEP, 72 hour rainfall event with a dry freeboard of 0.6 m. In addition, the cell is designed with an emergency spillway located 0.3 m below the embankment crest, however hydrological modelling (Talis, 2019) indicates there is sufficient storage capacity at the perimeter embankment, with the capability of storing in excess of the*

*1:2,000 AEP flood event with 0.66 m dry freeboard.*

### 9.1.5 Specified restrictions

The following restrictions have been specified regarding discharges of water to the environment and disposal activities at the MRF (revised licence conditions (10, 19 & 20):

- Water within the dredge pond must not be discharged into Mullering Brook;
- Surface water runoff and/or leachate from the MRF must not be discharged into Mullering Brook or the dredge pond;
- Disposal of mineral processing residues and other specified hazardous wastes only.

***Note:*** *The restrictions specified above for discharges of water have been imposed in the absence of any details regarding discharge activities that may/may not have been assessed and/or authorised under previous Part V licenses.*

*DWER notes the majority of waste disposed at the MRF constitutes the waste residues from downstream processing, however the existing licence currently permits the disposal of "other inert wastes" and unspecified materials from the licence holder's other sites.*

***Grounds:*** *A review of Tronox internal operating procedures identified that on occasions, excess water from the dredge pond has been discharged into Mullering Brook. In addition, provisions have been made within the design of the more recent MRF pits for the discharge of surface water runoff and/or leachate during large rainfall events. DWER is unable to substantiate whether these activities have been explicitly risk assessed and/or authorised. Given the current water quality within the dredge pond (i.e. acidic, high salinity), it is unlikely to be considered acceptable under any circumstances.*

*As per the findings of DWER's review of the MRF, it is considered a dry stack TSF that has been specifically designed and constructed for the purpose of disposing mineral processing residues. It is not a landfill and therefore should not be considered as such. The assessed risk of the MRF is based on the known nature and characteristics of the residues, in addition to the actual amount and specified management. The disposal of other, unspecified wastes may alter the assessed risk. DWER has therefore determined to be specific in the waste types authorised for disposal at the MRF – being mineral processing residues and material/equipment from site activities that may have become contaminated by NORM, i.e. unsuitable for disposal at a municipal landfill.*

### 9.1.6 Specified actions

The following actions have been specified to mitigate impacts on groundwater quality and amenity from operation of the dredge pond, MRF and other mining activities (revised licence conditions 11, 12, 21, 22, 29 and 30):

- Remedial actions to ensure water quality within the dredge pond is maintained above pH 4.5, with an average monthly pH of ≥5.0 (to be based on fortnightly measurements);
- Minimise dust generation within the MRF, and to ensure such dust is not visible outside of the MRF area;
- Minimise disturbance and/or generation of acid sulfate soils, including active management of identified PASS and treatment (neutralisation) of overburden and clay fines; and
- Minimise dust generation during topsoil stripping, rehabilitation activities and stockpiles.

***Note:*** *The actions specified above generally replicate existing licence holder management measures, and have been determined as being required to mitigate potential risks identified in this decision report. DWER has, however, determined to impose a higher level of control on some aspects.*

***Grounds:***

- *DWER has considered the licence holder's existing management strategy for addressing* *the acid sulfate-related issues at the dredge pond and has determined to impose an outcome-based condition, based on the key recommendations of DWER's risk assessment for ASS, i.e. pH of the dredge pond should be maintained above 5.0, as opposed to prescribing specific controls through the licence. DWER notes that neutralisation efforts to date have seen the pH artificially maintained around 4.5 – 5.5, however it is considered that further efforts are required in order to increase the pH and buffering capacity to levels that will reduce the risk of a) further acidification taking place, and b) the leaching of some metals and radium from fine sediments into solution.*

- *MRF dust is likely to present potential inorganic and radiation hazards (due to low levels of heavy metals and NORM in its raw form) – the controls specified in Table 8 of the revised licence are therefore considered necessary in order to reduce the risk of impacts from MRF dust on nearby ecological receptors. In addition, a review of Tronox internal operating procedures for airborne dust identified a performance standard that "no dust from the MRF is to be visible at 1 km from the pits". DWER considers this standard to be unacceptable (given the potential inorganic and radiation hazard) and has imposed a requirement to contain dust within the MRF area (specified Schedule 1 of the revised licence).*
- *Recent ASS investigations indicate the presence of sulfides along the proposed mine path, within the upper 1 – 5 m of the soil profile. The controls specified in Condition 27 of the revised licence are considered necessary for minimising the risk of further acidification from the disturbance of ASS during future mining. In addition, a review of Tronox's internal management procedures for PASS (South Mine ASSMP) identified that clay fines are not treated with lime (i.e. neutralised) if they are to be disposed at the base of a mined pit, on the understanding that it will not impact on rehabilitation. DWER considers this may be the case if the material is deposited below the water table, however there is a significant risk that residual sulfides will oxidise and release acid if disposed above the water table.*
- *The dust controls specified in condition 28 of the revised licence are consistent with the operation of mineral sands mines across the State, and are not considered to be overly onerous. The key control relates to minimising the generation of visible dust 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 this risk. The sampling of dust levels along the Premises boundary is consistent with existing monitoring conducted by the licence holder, and is considered necessary to provide assurance over the effectiveness of dust controls specified in Condition 28.*

### 9.1.7 Monitoring requirements

General monitoring

A number of conditions have been applied to the revised licence (conditions 14, 24, 31 and 32) to prescribe the minimum monitoring requirements. They relate to the minimum requirements for sampling and analysis, minimum timeframes between sampling events, and calibrations requirements for instruments used by the licence holder.

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

Dredge pond

Monitoring of water quality within the dredge pond has been specified in the revised licence (conditions 13 – 16), including:

- Routine monitoring of pH, acidity, alkalinity (fortnightly), dissolved oxygen, salinity and temperature (monthly);
- Conducting an assessment and trend analysis of all results; and

- Substantiating the number and location of sampling points (i.e. sufficient to demonstrate the horizontal and vertical variation across the dredge pond).

***Note:*** *The licence holder currently conducts monitoring of water quality within the dredge pond, however this is not a requirement of the existing licence.*

***Grounds:*** *As discussed above in section 7.1.2, the very large scatter of pH values measured in the dredge pond suggests there are issues with how levels of acidity are measured. It is unclear what the dredge pond sampling program involves, and whether it is sufficient to determine if the current lime dosing programme is well targeted.*

*DWER has therefore determined to prescribe the monitoring programme for the dredge pond, to ensure that sufficient data is being gathered to enable an improved understanding of the physical and chemical processes occurring within and across the entire dredge pond. This information is then expected to determine the suitability and effectiveness of management actions.*

Mineral Residue Facility – dust

Monitoring of dust from the MRF has been specified in the revised licence (condition 25), in existing locations surrounding the facility.

***Grounds:*** *The sampling of dust levels within proximity to the MRF is consistent with existing monitoring conducted by the licence holder, and is considered necessary to provide assurance over the effectiveness of dust controls at the MRF.*

Mineral Residue Facility – groundwater

Monitoring of groundwater quality in proximity to the MRF has been specified in the revised licence (Condition 23), including:

- Routine monitoring of physical and chemical parameters (major ions), including metals and metalloids; and
- Conducting an assessment and trend analysis of all results against historical data and relevant environmental standards.

***Note:*** *The licence holder currently conducts monitoring of groundwater quality from the "WMB" series of bores, however the existing licence is not specific in terms of which bores are to be monitored for the purpose of detecting impacts from the MRF.*

***Grounds:*** *DWER has determined to specify the monitoring of existing bores it considers to be most relevant for detecting potential contamination of shallow groundwater from the MRF. The monitoring specified in the revised licence essentially duplicates the existing requirements as specified in the GOS, however this is subject to change as new information becomes available from further groundwater investigations.*

Ambient environmental monitoring

Monitoring of ambient groundwater quality has been specified in the revised licence (condition 33), requiring monitoring of groundwater in bores as the mine path progresses.

***Note:*** *There is a large network of groundwater monitoring bores across the Premises, which are currently being monitored for various objectives in accordance with the site's GOS. The existing licence is not specific in terms of which bores are to be monitored for the purpose of detecting impacts of the mining operation.*

***Grounds:*** *DWER has determined that, given the progressive nature of the dredge mining operation, and the difficulties in prescribing a set groundwater monitoring program over such a large area, it would be more practical to stipulate monitoring of bores relative to the active dredge pond, i.e. upgradient, downgradient, pre and post mining). Monitoring results will be read in conjunction with monitoring conducted under the GOS.*

### 9.1.8 Investigations

An investigation into the leakage rate of water from the dredge pond in the surrounding aquifer is required (conditions 17 & 18).

***Note:*** *This investigation is considered necessary for determining the extent of known and potential impacts identified in this Decision Report (from current and historic mining activities).*

***Grounds:***

*Following DWER's review into the acid sulfate-related issues within the dredge pond, it was initially proposed to impose a condition that required the licence holder to maintain a pH value in the dredge pond greater than 6.0. It was acknowledged this would be very difficult to achieve, with this value being much higher than the pH values of the surrounding groundwater.*

*The licence holder then proposed what it considered to be a more realistic and achievable control where the dredge pond pH is maintained above 4.5, with an average monthly pH of ≥5.0 based on fortnightly measurements. DWER considered this could be acceptable, providing there was also a commitment to maintain some residual alkalinity in the dredge pond (at least 30 mg/L as $CaCO_3$) to minimise the export of acidity and dissolved metals from the pond into the surrounding groundwater. The licence holder advised that based on monitoring data from 2015 this was also was not achievable, with results indicating that based on 71 sampling records, the highest measured alkalinity value was 12 mg/L, with more than half of these records being less than the limit of reporting (i.e. below 1 mg/L).*

*The licence holder suggested this requirement be replaced with a study to review the role alkalinity plays in dredge pond acidity management. DWER considers there is already literature available that indicates this, and that it is more the extent to which the acidic, metalliferous water leaks from the pond into the adjacent aquifer that is currently poorly quantified. It would therefore be more beneficial to determine the leakage rate, in order to estimate the likely long-term impacts of seepage from the dredge pond using reactive transport modelling. This could be done by assessing differences in the chemical composition between the pond water and groundwater in the shallow aquifer, and then developing a mixing model which would use the pond water and natural groundwater as end-members in the model. The most sensitive parameters for doing this would be to look at differences in the stable isotope composition of water in the pond and in natural groundwater (180 and deuterium), which is similar to studies conducted by CSIRO to assess the interaction of wetlands with groundwater on the southern Swan Coastal Plain.*

### 9.1.9 Record-keeping

A number of conditions have been applied to the revised licence (Conditions 36 – 40) to prescribe the minimum record keeping requirements. They relate to the standards for book-keeping, the requirement to implement a suitable complaints management procedure, the requirement to submit an annual environmental report and annual audit compliance report, and the requirement to produce records to the CEO upon request.

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

# 10. Licence holder's comments

The licence holder was provided with drafts of the decision report and revised licence in November 2018. A meeting was held between DWER and the licence holder on 16 April 2019 to discuss the content of the drafts, prior to the licence holder providing formal comments which are summarised, along with DWER's response, in Appendix 2.

# 11. Conclusion

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

This assessment was also informed by a site visit by DWER officers on 18 May 2017, in addition to annual site visits as part of MSARCC meetings.

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

***Tim Gentle***
***MANAGER RESOURCE INDUSTRIES***
***REGULATORY SERVICES***

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

# Appendix 1: Key documents



| | Document title | In text ref | Availability |
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| 1. | Appelo, C.A.J. and Postma, D., 2005. *Geochemistry Groundwater and Pollution*. Balkema Publishers. | Appelo and Postma, 2005 | accessed at: www.elsevier.com/locate/envpol |
| 2. | Appleyard, S. and Cook, T., 2008. Reassessing the management of groundwater use from sandy aquifers: acidification and base-cation depletion exacerbated by drought and groundwater withdrawal on the Gnangara Mound, Western Australia. *Hydrogeology Journal*, **17**, 579-588. | Appleyard and Cook, 2008 | |
| 3. | ANZECC/NHMRC, 1992. Australian and New Zealand Guidelines for the Assessment and Management of Contaminated Sites. | ANZECC/ NHRMC, 1992 | accessed at: www.nhmrc.gov.au/guidelines |
| 4. | DEC, 2009. Landfill Waste Classification and Waste Definitions 1996 (As amended December 2009). Department of Environment and Conservation, Perth | DEC, 2009 | accessed at: www.dwer.wa.gov.au |
| 5. | DEC, 2012. Investigation and Management of Acid Sulfate Soil Hazards Associated With Silica and Heavy Mineral Sand Mining Operations (DRAFT). Department of Environment and Conservation, Perth. | DEC, 2012 | DWER internal records |
| 6. | DEC, 2013. Notice of a classification of a known or suspected contaminated site given under section 15 of the *Contaminated Sites Act 2003*. | DEC, 2013 | DWER records (DMO2691) |
| 7. | DER, December 2014. Assessment and management of contaminated sites – Contaminated Sites Guidelines. Department of Environment Regulation, Perth. | DER, 2014 | accessed at: www.dwer.wa.gov.au |
| 8. | DER, June 2015. Identification and investigation of acid sulfate soils and acidic landscapes. Department of Environment Regulation, Perth. | DER, 2015a | |
| 9. | DER, June 2015. Treatment and management of soils and water in acid sulfate soil landscapes. Department of Environment Regulation, Perth. | DER, 2015b | |
| 10. | DER, July 2015. Guidance Statement: Regulatory principles. Department of Environment Regulation, Perth. | DER, 2015c | |
| 11. | DER, October 2015. Guidance Statement: Setting conditions. Department of Environment Regulation, Perth. | DER, 2015d | |
| 12. | DER, August 2016. Guidance Statement: Licence duration. Department of Environment Regulation, Perth. | DER, 2016a | |
| 13. | DER, February 2017. Guidance Statement: Risk Assessments. Department of | DER, 2017a | |

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| | Environment Regulation, Perth. | | |
| 14. | DER, February 2017. Guidance Statement: Decision Making. Department of Environment Regulation, Perth. | DER 2017b | |
| 15. | DWER, March 2017. Technical advice: Licence Review – Cooljarloo Mineral Sands Mine | DWER, 2017a | DWER records A1390552 |
| 16. | DWER, April 2017. Technical advice Addendum: Licence Review – Cooljarloo Mineral Sands Mine | DWER, 2017b | DWER records A1422442 |
| 17. | EPA Bulletin 330. Report and Recommendations of the Environmental Protection Authority – Cooljarloo Mineral Sands Project, TiO2 Corporation NL (March 1988) | Bulletin 330 | accessed at: www.epa.wa.gov.au |
| 18. | EPA Bulletin 990. Report and Recommendations of the Environmental Protection Authority – Cooljarloo Mineral Sands Mine, Mining of Titanium Minerals, Orebodies 27 200 and 28 000 (September 2000) | Bulletin 990 | |
| 19. | EPA Report 1299. Report and Recommendations of the Environmental Protection Authority – Cooljarloo Mine – Falcon Extension (August 2008) | Bulletin 1299 | |
| 20. | Geurts, J.J.M., Sarneel, J.M., Willers, B.J.C., Roelofs, J.G.M., Verhoeven, J.T.A., & Lamers, L.P.M., 2009. Interacting effects of sulphate pollution, sulphide toxicity and eutrophication on vegetation development in fens, A mesocosm experiment. *Environmental Pollution*, 157, 2072-2081 | Geurts *et al*., 2009 | accessed at: www.elsevier.com/locate/envpol |
| 21. | Golder Associates, August 2000. Report on Black Waste Pit – Cooljarloo Mine Site, Dandaragan, Western Australia. Prepared for the Tiwest Joint Venture by Golder Associates Pty Ltd | Golder Associates, 2000 | DWER records A1632683 |
| 22. | HGEO, 2018. Cooljarloo Mine - Annual Aquifer Review 2017. Prepared for Tronox Pty Ltd by HGEO Pty Ltd | HGEO, 2018 | DWER records A1685791 |
| 23. | HGM, April 1996. Cooljarloo Mine Site – Report on Investigations into Potential for Leaching of Black Waste. Prepared for the Tiwest Joint Venture by Halpern Glick Maunsell Pty Ltd | HGM, 1996 | DWER records A1632689 |
| 24. | HGM, October 2002. Cooljarloo Mine Site – Report on Investigations into Potential for Leaching of Black Waste. Prepared for the Tiwest Joint Venture by Halpern Glick Maunsell Pty Ltd | HGM, 2002 | DWER records A1632687 |
| 25. | HSE, May 2012. Environmental Noise Impact Assessment – Tiwest Joint Venture, Cooljarloo WA. Prepared for the Tiwest Joint Venture by Health Safety Environment | HSE, 2012 | DWER records A1685786 |

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| | Australia Pty Ltd | | |
| 26. | Kern, A.M., 1993. The geology and hydrogeology of the superficial formations between Cervantes and Lancelin, Western Australia. Geological Survey of Western Australia | Kern, 1993 | accessed at: www.dmirs.wa.gov.au |
| 27. | Licence L5319/1988/12 – Cooljarloo Mineral Sands Mine | Existing Licence | accessed at: www.der.wa.gov.au |
| 28. | *Mineral Sands (Cooljarloo) Mining and Processing Agreement Act 1988* | State Agreement | accessed at: www.slp.wa.gov.au |
| 29. | Ministerial Statement 37 | MS 37 | accessed at: www.epa.wa.gov.au |
| 30. | Ministerial Statement 557 | MS 557 | |
| 31. | Ministerial Statement 790 | MS 790 | |
| 32. | Ministerial Statement 977 | MS 977 | |
| 33. | MWES, March 2016. Cooljarloo Mine – Triennial Aquifer Review 2013 – 2015. Prepared for Tronox Management Pty Ltd by MWES Consulting | MWES, 2016a | DWER records A1071519 |
| 34. | MWES, August 2016. Investigation of rising groundwater salinity – Bore MSB10D – Cooljarloo Mine Site. Prepared for Tronox Management Pty Ltd by MWES Consulting | MWES, 2016b | DWER records A1632690 |
| 35. | NHMRC & NRMMC, 2011. Australian Drinking Water Guidelines – updated October 2017. National Health and Medical Research Council, | NHRMC & NRMMC, 2011 | accessed at: www.nhmrc.gov.au/guidelines |
| 36. | Parsons Brinckerhoff, March 2013. Cooljarloo Triennial Aquifer Review 2010 – 2012. Prepared for Tronox Management Pty Ltd by Parsons Brinckerhoff Australia Pty Ltd | PB, 2013 | DWER records A1071512 |
| 37. | Parsons Brinckerhoff, April 2015. Cooljarloo Water Resource Operating Strategy. Prepared for Tronox Management Pty Ltd by Parsons Brinckerhoff Australia Pty Ltd | PB, 2015 | DWER records A1390490 |
| 38. | PPK, July 2001. Hydrogeology of Cooljarloo Mine Site. Prepared for Tiwest Joint Venture by PPK Environment & Infrastructure Pty Ltd | PPK, 2001a | DWER records A1632688 |
| 39. | PPK, September 2001. Long Term Management of Black Waste Leachate – A Risk Based Approach. Prepared for the Tiwest Joint Venture by Parsons Brinckerhoff International (Australia) Pty Ltd | PPK, 2001b | DWER records A1632686 |
| 40. | Salmon, S.U., Rate, A.W., Rengel, Z, Appleyard, S., Prommer, H. and Hinz, C., 2014. Reactive transport controls on sandy acid sulfate soils and impacts on shallow groundwater quality. *Water Resources Research*, **50**, 4924-4952. | Salmon, *et al*. 2015 | accessed at: www.elsevier.com/locate/envpol |
| 41. | Schaberg, P.G., DeHayes, D.H. and Hawley, G.J., 2001. Anthropogenic calcium depletion: a unique threat to forest ecosystem health? CWEM Wiley, | Schavberg, *et al.* 2001 | |

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| 43. | SWC, March 2015. South Mine ASS Management Plan. Prepared for Tronox Management Pty Ltd by Soilwater Consultants | SWC, 2015 | DWER records A1632680 |
| 44. | SWC, March 2017. Site 12 mining operations and potential impact on PASS and groundwater quality. Memo report prepared for Tronox Management by Soilwater Consultants | SWC, 2017 | DWER records A1652313 |
| 45. | SWC, March 2019. Cooljarloo Mine Dredge Pond PHREEQC Modelling. Prepared for Tronox Management by Soilwater Consultants | SWC, 2019 | DWER records A1846354 |
| 46. | Talis, October 2019. Mineral Residue Facility – Geotechnical Report. Prepared for Tronox Management Pty Ltd by Talis Consultants | Talis, 2019 | DWER records A1846347 |
| 47. | Tronox, July 2013. Cooljarloo Environmental Management Programme | Tronox, 2013 | DWER records A845074 |
| 48. | USGS, 2012. Principal aquifers can contribute radium to sources of drinking water under certain geochemical conditions. Fact Sheet 2010-3113, U.S. Geological Survey | USGS, 2012 | accessed at: https://pubs.usgs.gov |
| 49. | WRC, 2000. Water Quality Protection Guidelines for Mining and Mineral Processing – Liners for waste containment. Water and Rivers Commission, Perth | WRC, 2000 | accessed at: www.water.wa.gov.au |

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

| Element/Item | Pg | Licence Text | Tronox amendment requested #1 | Justification/Additional Information | DWER response #1 | Changes made to Revised Licence | Tronox response #2 | DWER response #2 and changes made to revised licence |
|---|---|---|---|---|---|---|---|---|
| Registered business address | Pg 1 | 1 Brodie Hall Drive BENTLEY WA 6102 | Registered Business Address is: Lot 22 Mason Road, Kwinana Beach, WA 6167 | Tronox's registered business address has changed. | Noted. | Details updated as per Tronox request. | No comment. | N/A. |
| Duration 01/10/2012 to 30/09/2027 | Pg 1 | 01/10/2012 - 30/09/2027 | The amended licence extends to align with the life of the Mining tenure which will be to 2 Mar 2041 | It is Tronox's understanding that DWER policy is to match licence duration to that of the primary project authorisation which in this case is the Mining Lease.<br>The tenure for the Cooljarloo Mine (Mining Lease M268SA) is established pursuant to the *Mineral Sands (Cooljarloo) Mining and Mineral Processing Agreement Act 1988 (State Agreement)* which expires 1 March 2020. At this time M268Sa will also expire. On expiry, the State Agreement provides Tronox the right to grant of a Mining Lease granted pursuant to the Mining Act 1978 with corresponding rights, including term of tenure. | DWER's *Guidance Statement on Licence Duration* (DER, August 2016) provides for the granting of licences up to 20 years. The licence expiry for this site was extended by 20 years in 2016 as part of DWER's implementation of this guidance statement.<br>The transition to mining lease under the Mining Act upon expiry of the SAA is noted, however as the mining lease has not yet been granted, the licence will now be aligned with the primary authorisation for the project, being the SAA.<br>Following the grant of the mining tenure, the licence expiry can be amended to align with this expiry. | Licence expiry amended to align with SAA expiry. | Tronox seek advice and assistance regarding maintaining the existing licence during the transition from SAA to mining tenure and request to either delay issuing the revised licence until post the expiry of the SAA, or leave the current duration of the licence as per existing expiry (2027). | To avoid complication with the tenure transferral, the current licence expiry will remain unchanged (2027). |
| Black Waste Dump area | Pg 4 | means the area on the Premises that has been used for the disposal of tailings and other production wastes generated from downstream processing and refining of the mined sands (a.k.a. "black waste"), and depicted by the green dotted line in the Black Waste Dump map in Schedule 1 | Change the name of the facility to Mineral Residue Facility throughout the licence.<br>Proposed wording:<br>*means the area on the Premises that has been used for the disposal of tailings and other production wastes generated from downstream processing and refining of the mined sands (a.k.a. mineral processing residue), and depicted by the green dotted line in the Mineral Residue Facility map in Schedule 1* | Tronox's nomenclature refers to the Class III facility as a Mineral Residue Facility and requests DWER amend the nomenclature within the licence and Decision Report to reflect this. Similarly, the "black waste" is more correctly referred to as mineral processing residue. | Noted.<br>*N.B. DWER requests that all references to a "Class III landfill" cease following finalisation of this licence review, given it has been established by DWER and DMIRS the facility is a TSF and not a landfill.* | All references to Black Waste Dump and Black waste amended to Mineral Residue Facility and Mineral processing residue, throughout. | No comment. | N/A. |
| Condition 1 | Pg 7 | Table 2, Line Item 1<br>Disposal of mine tailings (waste sand and clay) - Only to the Dredge Pond, mine void(s) or solar drying pond(s) located on the Premises | Amend to:<br>*Disposal of mine tailings (sand and clay) – Only to the Dredge Pond, mine void(s), solar drying dams(s) and designated stockpile areas located on the Premises* | At times, Tronox dry stack sand tailings by way of cycloning stackers in designated stockpile areas for future use in landform construction and rehabilitation. To facilitate this existing activity, Tronox request the inclusion of "designated stockpile areas" in column 2.<br>DWER also assessed sand tailings to be low risk in Table 15 in the Decision Document "due to the absence of any significant leachable contaminants within the sand tailings" and deemed that a detailed risk assessment was not required nor were any controls outlined to minimise the risk. As such, the inherent risk for sand tailings is low, and therefore, conditions relating to the placement of sand tailings is | As discussed in our meeting on 16.4.19, DWER has assessed the risk of tailings disposal as low – based on the disposal being done in the manner and locations as assessed by DWER and per the Mine Closure Plan. A term such as 'designated stockpile area' is too ambiguous and would be difficult to enforce. | No changes proposed.<br>DWER would consider including the provision for tailings disposal in areas other than the dredge pond, mine void or SEPs, providing the specifics of what constitutes a 'designated stockpile area' can be made clear in a condition. | DWER to clarify this does not restrict the use of dry/dewatered clay and sand tails in landforming and rehabilitation outside the dredge pond, mine voids and solar drying dams, e.g. reconstructing the soil profile of areas such as laydown, stockpile and other cleared areas at closure. | Text added to Table 1 to clarify this requirement excludes the use of mine tailings for rehab of non-mining areas. |

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| | | | | not considered to be warranted in the licence. | | | | |
| Condition 1 | Pg 7 | Table 2, Line Item 2<br>Disposal of Black Waste - Only to the Black Waste Dump area (Pit 7 & Pit 7 Ext) and subject to compliance with Conditions 13 - 21 inclusive | Amend to:<br>*Disposal of Mineral Processing Residue - Only to the Mineral Residue Facility (Cell 7, Cell 7 Ext and Cell 8) and subject to compliance with Conditions 13 - 21 inclusive"* | Amend to reflect change in facility name and to include the new Cell 8 area.<br>Tronox currently has a Licence amendment application with DWER for the extension of the MRF. Tronox is currently preparing additional information in response to a request for information issued on 28 May 2019.<br>The additional information will be provided shortly and Tronox requests the information be considered prior to issuing the revised licence to enable the Cell 8 MRF expansion to be included. | Cell 8 has not been approved yet so this will not be added to the licence until it has been constructed and construction has been certified. | Facility name changed.<br>No other changes proposed. | Tronox understand Cell 8 extension approval will form part of the revised licence. | The revised licence will authorise construction of Cell 8, however a separate licence amendment will be required following construction and certification of the works, prior to use. |
| Condition 1 | Pg 7 | Table 2, Line Item 3<br>Indirect emissions to groundwater from seepage - Only from the Dredge Pond and solar drying ponds specified in Table 4 | Amend condition to:<br>*Indirect emissions to groundwater from seepage - Only from the Dredge pond, voids, solar drying dams, tailings areas and Mineral Residue Facility.* | For completeness, Tronox requests the inclusion of mine voids, tailings areas and the MRF as they have the potential for indirect emissions to groundwater from seepage similar to the dredge pond and solar drying dams.<br>Tronox seeks clarification regarding the implications of this condition as it pertains to potential future or historical indirect emissions to groundwater from the MRF. The decision document states DWER's position regarding potential salinity impacts to groundwater below the MRF. As such, the omission of the MRF from the list of "indirect emissions to groundwater" renders the site non-compliant once the revised licence is issued. The condition in its current form could be interpreted to not allow for any indirect emissions from mine voids, tailings areas and the MRF irrespective of environmental impact/harm. Tronox requests clarification regarding the intent and implementation of this condition. | Specified emissions are those which DWER has determined to be acceptable through its risk assessment framework, providing they are emitted/discharged in accordance with controls that are specified in the licence. All other emissions that may occur from time to time should be considered 'general emissions' and they would need to comply with the requirements specified in Table 2.<br>In terms of the MRF - it is an engineered containment facility and is designed to contain seepage - DWER therefore expects the facility to be designed and constructed in a manner that prevents/limits/mitigates seepage from occurring, and that is why seepage from the MRF is not a specified emission.<br>As a general emission it would not be an offence if seepage occurs from the MRF, however if it does it would need to be done so in accordance with the criteria as specified for general emissions in Table 2. If it seeps and causes contamination, pollution, environmental harm, etc. then the defence provisions of s74, 74A and 74B would not apply. | No changes proposed. | No comment. | N/A. |
| Condition 2 & 3 | Pg 8 | Table 3, Dot Point 1<br>Solar drying ponds:<br>• Must be constructed within previous mine voids or on-mine-path; | Tronox requests this condition be removed from the licence as it unnecessarily restricts the operational flexibility of the site. | While recognising it is preferential to build solar drying dams on mine path (within areas mined or planned to be mined in the future), as it reduces the disturbance footprint of the mine, Tronox do not agree to this restriction, nor consider it to significantly reduce the environmental risk posed by the solar drying dams.<br>Under some circumstances, and to ensure the efficient operation of the mine, Tronox may be required to construct solar drying dams outside of mine voids and off mine path. All the solar drying dams are constructed, | DWER has assessed the risk of solar drying ponds being constructed within previous mine voids or on-mine path, and considers the risk of impacts to environmental receptors to be much higher if constructed in other (i.e. more sensitive) areas. The controls proposed in the Revised Licence for construction and operation of solar drying ponds located within previous mine voids or on-mine path are considered to be minimum requirements. | No changes proposed.<br>Tronox would need to specify the 'circumstances' under which there would be a requirement to construct a solar drying pond outside of these areas, for DWER's consideration, and possible inclusion in the Revised Licence. | Accepted. In the event a solar drying dam needs to be located off-site a works approval will be sought. | Nil. |

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| | | | | operated and monitored in accordance with DMIRS standards irrespective of their location on or off mine path. This ensures each solar drying dam irrespective of its location, poses a low environment risk. | | | | |
| Condition 2 & 3 | Pg 8 | Table 3, Dot Point 2, 3 and 4<br>Solar drying ponds:<br>• Pond floors must be constructed with a minimum slope of 1:300;<br>• Embankment walls must be constructed with compacted overburden or clayey sand (containing a fines content of < 30%) with angle of repose for the outer pond wall being at least 1:3 (V:H);<br>• Embankment wall height must not exceed 5 metres. | Tronox requests this condition be removed from the licence as it unnecessarily restricts the operational flexibility of the site. In additional, the design and construction of tailings storage facilities are regulated by DMIRS. The duplicate regulation by DWER is not considered to provide additional environmental risk mitigation. | The design and constructions requirements for solar drying dams (which are classified as tailings storage facilities) is regulated by the Department of Mines, Industry Regulation and Safety (DMIRS). The legal requirements pertaining to tailings storage facilities are contained in the *Mines Safety and Inspection Act 1994* and *Mining Act 1978* which are relevant to the Cooljarloo operation.<br>As per DMIRS requirements, all TSFs at Cooljarloo are designed and assessed by a "competent person" to ensure the facilities satisfy the safety requirements of the *Mines Safety and Inspection Act 1994* and regulations and the environmental requirements of the *Mining Act 1978* and regulations. | There are three points to address this:<br>1. Section 53(1)(b)(i) of the EP Act requires a works approval for the construction of any waste containment infrastructure, including TSFs. The inclusion of these construction requirements in the Revised Licence provides an ongoing authorisation to construct additional TSFs on the Premises, without the need to apply for separate works approvals for future TSFs.<br>2. The design and construction requirements for TSFs are co-regulated by DMIRS and DWER. DMIRS requirements for geotechnical audits and review of design under the Mines Safety and Inspection Act are done to ensure the safety of a structure. Mining Proposals under the Mining Act primarily review aspects associated with clearing (siting of the TSF) and mine closure and may regulate seepage, but in practice this is left to DWER to regulate under the EP Act. To make it clearer, DWER stipulates key design requirements to address seepage and to mitigate/minimise the risk of other operational discharges such as overtopping or from embankment failure.<br>3. DMIRS has advised that as the site is on state agreement tenement, there is no mechanism in place to require regular, detailed reviews of TSF design, construction and audit reports that are normally covered by tenement conditions under the Mining Act – DMIRS advises it has not conducted a detailed assessment of the TSF process or an ongoing review of TSF management practice at this site since 2013. | No changes proposed. | Accepted. | N/A. |
| Condition 4 | Pg 8 | Table 4, Mining Infrastructure, Line Item 1, Dot Point 1 and 2<br>Suction-cutter dredges:<br>• Cooljarloo I (1,680 t/hr capacity)<br>• Cooljarloo II (500 t/hr capacity) | Tronox requests this condition be amended to reflect the actual maximum capacity of the two dredges and to correct one of the dredge names.<br>Proposed amendment:<br>*• Cooljarloo I (6,000 t/hr capacity)* | - | Noted. | Condition amended as per Tronox request. | No comment. | N/A. |

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| | | | • *Pelican (2,000 t/hr capacity)* | | | | | |
| Condition 4 | Pg 8 | Table 4, Mining Infrastructure, Line Item 2<br>Wet concentrator plant:<br>• Floating concentrator (1,900 t/hr capacity) | Tronox requests this condition be amended to reflect the actual maximum capacity of the Wet Concentrator.<br>Proposed amendment:<br>• Floating concentrator (4,200 t/hr capacity) | - | Noted. | Condition amended as per Tronox request. | No comment. | N/A. |
| Condition 4 | Pg 8 | Table 4, Mining Infrastructure, Line Item 6<br>HMC stockpile pad:<br>• Drainage designed to divert surface water runoff to a lined collection sump sufficient to contain a 1% AEP | Tronox requests this condition be amended to remove the requirement for a lined sump to reflect the low risk posed by this activity.<br>Proposed amendment:<br>• *Drainage designed to divert surface water runoff to a collection sump for subsequent solids settling and reuse on site.* | Surface water runoff from HMC stockpiles area is collected by drains and sumps and transferred via pumps and pipes to the dredge pond or other water storage voids (dependant on dredge pond and HMC stockpile location as the mine progresses) for reuse. These are not lined.<br>The quality of surface water at the HMC stockpile is similar to that in the dredge pond and other water filled voids onsite, and is not considered of sufficient risk to justify a lined sump. Runoff from the HMC stockpiles is reused in processing.<br>The low risk posed by the HMC stockpile runoff is also recognised in Table 15 of the Decision Document, which confirms the existing controls Tronox have in place are adequate. These controls do not include a lined sump to capture surface water runoff from the HMC stockpile pad. | Noted. | The requirement for a lined sump to collect surface water runoff from the HMC stockpile(s) has been removed.<br>The requirement for surface water runoff to pass through a sediment control structure has been added. | Accepted. | Nil. |
| Condition 4 | Pg 8 & 9 | Table 4, Tailings Infrastructure, Line Item 1, Dot Point 1<br>Solar drying ponds:<br>• Temporary ponds to allow the drying of clay fines | Tronox requests the name of the mining infrastructure be amended to "Solar Drying Dams" in this condition and throughout the document.<br>Proposed amendment:<br>*Solar drying dams:*<br>• Temporary dams to allow the drying of clay fines | Align nomenclature to that used by Tronox, Solar Drying Dams. | Noted. | Condition amended as per Tronox request. | No comment. | N/A. |
| Condition 4 | Pg 9 | Table 4, Tailings Infrastructure, Line Item 1, Dot Point 2 & 3<br>Solar drying ponds:<br>• Top of embankment (total) freeboard of at least 500 mm must be maintained at all times<br>• Decant weir boxes and overflow drains to the Dredge Pond or return water pond | Tronox requests this condition be removed from the licence as it unnecessarily restricts the operational flexibility of the site. In additional, the design and construction of tailings storage facilities are regulated by DMIRS. The duplicate regulation by DWER is not considered to provide additional environmental risk mitigation. | The design and constructions requirements for solar drying dams (which are classified as tailings storage facilities) is regulated by the Department of Mines, Industry Regulation and Safety (DMIRS). The legal requirements pertaining to tailings storage facilities are contained in the *Mines Safety and Inspection Act 1994* and *Mining Act 1978* which are relevant to the Cooljarloo operation.<br>As per DMIRS requirements, all TSFs at Cooljarloo are designed and assessed by a "competent person" to ensure the facilities satisfy the safety requirements of the *Mines Safety and Inspection Act 1994* and regulations and the environmental requirements of the *Mining Act 1978* and regulations.<br>As an example, alternative infrastructure can be utilised instead | As discussed above, the design and construction requirements for TSFs are co-regulated by DMIRS and DWER.<br>In this instance, DWER has determined to stipulate key design requirements for solar drying ponds to address water management and minimise the risk of uncontrolled discharges such as overtopping and embankment failure.<br>The controls proposed in the Revised Licence are considered to be industry standard and are not intended to unnecessarily restrict the operational flexibility of the site. | No changes proposed.<br>DWER will consider alternative infrastructure proposed by Tronox for possible inclusion in the Revised Licence. | Accepted. | Nil. |

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| | | | | of Decant weir boxes and overflow drains to transfer water from these facilities. This condition will restrict that ability unnecessarily. | | | | |
| Condition 4 | Pg 9 | Table 4, Waste Containment Infrastructure, Line Item 1, Dot Point 1<br>Black Waste Dump:<br>• A large tailings storage facility located within Mullering Farm | Tronox requests "Black Waste Dump (BWD)" be amended to "Mineral Residue Facility (MRF)" and change the descriptor to reflect the materials contained in the facility.<br>Proposed amendment:<br>*Mineral Residue Facility:*<br>*• A mineral processing residue storage facility located within Mullering Farm* | Tronox have changed the nomenclature for the Black Waste Dump to the Mineral Residue Facility (MRF) to better describe the activity and requests DWER to adopt the same nomenclature within this licence and decision document to avoid misinterpretation. | Noted. | All references to BWD have now been changed to MRF.<br>Description changed to 'a large TSF located within Mullering Farm for disposal of mineral processing residues' | Accepted. | Nil. |
| Condition 4 | Pg 9 | Table 4, Waste Containment Infrastructure, Line Item 1, Dot Point 2<br>Black Waste Dump:<br>• Disposal must only take place within "Pit 7" or "Pit 7 Ext", as shown in the Black Waste Dump map in Schedule 1 | Proposed amendment<br>*Mineral Residue Facility:*<br>*• Disposal must only take place within "Pit 7", "Pit 7 Ext" and Pit 8, as shown in the Mineral Residue Facility map in Schedule 1* | Tronox currently has a Licence amendment application with DWER for the extension of the MRF. Tronox is currently preparing additional information in response to a request for information issued on 28 May 2019.<br>The additional information will be provided shortly and Tronox requests the information be considered prior to issuing the revised licence to enable the Cell 8 MRF expansion to be included. | As Cell 8 is yet to be assessed and approved, it will not be added to the licence as an authorised disposal location until it has been constructed and construction has been certified. | No changes proposed. | Tronox understand Cell 8 extension approval will form part of the revised licence. | The revised licence will authorise construction of Cell 8, however a separate licence amendment will be required following construction and certification of the works, prior to use. |
| Condition 4 | Pg 9 | Table 4, Waste Containment Infrastructure, Line Item 1, Dot Point 3<br>Black Waste Dump:<br>• Surface water runoff and leachate to be contained within the Black Waste Dump area – drainage to a lined collection sump sufficient to contain a 1% AEP | Proposed amendment<br>*Mineral Residue Facility:*<br>*Surface water runoff and leachate to be contained within the Mineral Residue Facility or clay lined collection sump sufficient to contain a 1% AEP.* | The proposed amendment allows for stormwater to be contained within the MRF cells, and provides the ability to construct separate clay lined collection sumps as and when water storage capacity in the cells is diminished overtime due to the disposal of Mineral Residue. | Additional design and construction details are required for 'clay lined collection sump' for DWER's consideration and possible inclusion in the Revised Licence. | No changes proposed. | The current wording is unclear. If a separate lined sump is required, Tronox will apply for a works approval.<br>Amend to: surface water runoff and leachate to be contained within the MRF. | Amended to: surface water runoff and leachate must be contained within the MRF perimeter embankment area. |
| Condition 5 | Pg 9 | The Licence Holder must undertake inspections:<br>a) of the scope specified in Column 1 of Table 5;<br>b) of the type specified in Column 2 of Table 5; and<br>c) at the frequency specified in Column 3 of Table 5.<br>In addition, where any inspection identifies the required level of environmental protection is not being maintained, the Licence Holder must:<br>d) take corrective action to mitigate adverse environmental consequences as soon as practicable; and<br>e) maintain a written log of all inspections undertaken, with each | Tronox requests this condition be removed from the licence | Remove condition for reasons outlined below pertaining to Table 5.<br>The risks DWER deemed will be controlled by the inspections are low, and as such, the administrative requirements of recorded daily inspections are not warranted. | As discussed at our meeting on 16.4.19, the reason the risk has been determined to be low is because of these controls being in place.<br>In accordance with DWER's Guidance Statement: Risk Assessments (DER, 2017), as the proposed controls lower the risk, they will be imposed on the licence. | No changes proposed. | Accepted. | Nil. |

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| | | inspection signed off by the person who conducted the inspection. | | | | | | |
| Condition 5 | Pg 9 | Table 5, Line Item 1 and 2<br>Pipelines carrying HMC and tailings; and<br>Return water pipelines:<br>Inspection:<br>• Visual integrity and leak assessment – Daily whilst operating / Monthly if not operating | Tronox requests this condition be removed from the licence | Appropriate controls, leak detection and telemetry systems, are already included in the licence to manage the risk of pipeline failures. Daily visual inspections are impracticable due to the sheer extent of pipeline infrastructure onsite and not justifiable considering the low risk posed.<br>Table 15 of the Decision document states that a detailed risk assessment was not required. Low risk events are acceptable and will generally not be subject to regulatory controls. Considering the low risk rating and existing leak detection controls in place, Tronox does not agree with the inclusion of this condition. | As discussed at our meeting on 16.4.19, the reason the risk has been determined to be low is because of these controls being in place.<br>In accordance with DWER's Guidance Statement: Risk Assessments (DER, 2017), as the proposed controls lower the risk, they will be imposed on the licence. | No changes proposed. | Accepted. | Nil. |
| Condition 5 | Pg 9 | Table 5, Line Item 3<br>Process water pond(s), return water pond:<br>Inspection:<br>• Visual integrity and leak assessment – Daily whilst operating / Monthly if not operating | Tronox requests this condition be removed from the licence | Process water ponds and mine voids pose a low risk of failure and conditioning daily integrity inspections of these ponds is not aligned with the risk. These ponds are constructed below the natural ground level and not susceptible to failure like above ground dams or impoundment structures.<br>Table 15 in the Decision document does not identify process water ponds and mine voids as a having a significant risk of failure to warrant daily integrity inspections. | Noted. | This requirement has now been removed. | No comment. | N/A. |
| Condition 5 | Pg 9 | Table 5, Line Item 4<br>Solar drying ponds:<br>Inspection:<br>• Visual integrity and leak assessment – Daily whilst operating / Monthly if not operating<br>• Freeboard capacity – Daily whilst operating / Monthly if not operating | Tronox requests this condition be removed from the licence. | Weekly inspections of the solar drying dams is undertaken in accordance with the Department of Mines, Industry Regulation and Safety (DMIRS) requirements. As such, Tronox requests this condition be removed to prevent conflicting and or duplicate requirements between DMIRS and DWER. | Noted, however the scope and type of inspections is different – DMIRS inspection requirements are from a safety perspective for ensuring the TSF remains a stable structure, whereas DWER inspections are focused on identifying issues that could result in environmental impacts.<br>In accordance with DWER's Guidance Statement: Risk Assessments (DER, 2017), as the proposed controls lower the risk, they will be imposed on the licence. | No changes proposed. | Accepted. | Nil. |
| Condition 5 | Pg 9 | Table 5, Line Item 5<br>Liquid chemicals/hydrocarbon storage areas on the dredges and wet concentrator<br>Inspection:<br>• Actual or identifiable hydrocarbon losses | Tronox requests this condition be removed from the licence | The risk of adverse impacts from chemical/hydrocarbon storage is considered to be low (confirmed in Table 15 of the Decision Document). Only minor volumes for grease/diesel are stored on the equipment and do not pose a material risk to the environment. As such, Tronox considers the inclusion of this condition to be inappropriate. | This control has been added to enable early detection and proactive management of hydrocarbon spills on the dredge pond, such as hydraulic oil spills.<br>In accordance with DWER's Guidance Statement: Risk Assessments (DER, 2017), as the proposed controls lower the risk, they will be imposed on the licence. | No changes proposed. | Accepted. | Nil. |

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| Condition 7 | Pg 10 | The Licence Holder must take remedial actions to ensure water quality within the Dredge Pond, as measured in accordance with Condition 8, is maintained ≥ pH 6.0 and total alkalinity ≥ 30 mg/L CaCO3, including but not limited to:<br>(a) dosing with lime slurry (neutralisation);<br>(b) de-sliming the Dredge Pond;<br>(c) reducing the size of the Dredge Pond;<br>(d) sub-dividing the Dredge Pond into sections; or<br>(e) other measures. | Tronox requests this condition be amended.<br>Proposed amendment:<br>*The Licence Holder must take remedial actions to ensure water quality within the Dredge Pond, as measured in accordance with Condition 8, is maintained at a pH >4.5 with an average monthly pH ≥ 5.0. The monthly pH value is to be based on fortnightly pH values.*<br>Management practices may include:<br>*(a) dosing with lime slurry (neutralisation);*<br>*(b) de-sliming the Dredge Pond;*<br>*(c) reducing the size of the Dredge Pond;*<br>*(d) sub-dividing the Dredge Pond into sections; or (e) other measures.* | Please refer to **Section 2 Condition 7 – Dredge Pond Monitoring and Reporting** for further information pertaining to this item. | It is acknowledged it could be difficult to maintain a pH in the dredge pond above 6 and this value is much higher than the current pH values in surrounding groundwater. However, it is important that some residual alkalinity is maintained in the dredge pond to minimise the export of acidity and dissolved metals into surrounding groundwater. | Condition reworded to:<br>*The Licence Holder must take remedial actions to ensure water quality within the Dredge Pond, as measured in accordance with Condition 8, is maintained at a pH >4.5 with an average monthly pH ≥ 5.0 <u>and a residual alkalinity value of ≥ 30 mg/L as $CaCO_3$</u>. The monthly pH <u>and alkalinity values</u> must be based on fortnightly measurements.*<br>*Management practices may include:*<br>*(a) dosing with lime slurry (neutralisation);*<br>*(b) de-sliming the Dredge Pond;*<br>*(c) reducing the size of the Dredge Pond;*<br>*(d) sub-dividing the Dredge Pond into sections; or (e) other measures.*<br>DWER considers the alkalinity measurements can be simply made using field test kits and therefore would not significantly increase the administrative burden on Tronox for maintaining this condition. | Tronox understands DWER's affinity to maintaining alkalinity >30 mg/L as CaCO3, however the introduction of this control in the licence would immediately make the mining operation non-compliant, as alkalinity measured in the dredge pond since 2010 has not returned one alkalinity reading above 30 mg/L.<br>Based on 71 records, 45 were reported below the limit of reporting. The highest was 12 mg/L recorded in April 2011. From 2015 monitoring has been undertaken on a monthly basis - 48 records collected from July 2015 indicate the following: average 1.3 mg/L, max. 9.0 mg/L, min <1 mg/L.<br>Since February 2019 alkalinity has been reported below the limit of reporting. Lime dosing was increased in July 2019 with 75 truck loads of lime being dosed in the pond 1 July – 5 November 2019 (average 1.7 loads per day). Throughout this time, alkalinity has remained below 1 mg/L.<br>Considering the significant challenges associated with the fulfilling of the proposed alkalinity requirement in the licence, Tronox request this requirement be replaced with the requirement to undertake a study to review the role alkalinity plays in dredge pond acidity management. | DWER does not see the point in undertaking a study of the role of alkalinity in controlling the chemistry of water in the dredge pond as there is already a large body of literature indicating this. The issue is the extent to which the acidic, metalliferous water leaks from the pond in the adjacent aquifer which is currently poorly quantified.<br>Therefore, there would be some merit in determining the leakage rate of water from the pond into the aquifer – this could be done by assessing differences in the chemical composition between the pond water and groundwater in the shallow aquifer, and then developing a mixing model using the pond water and natural groundwater as end-members in the model. The most sensitive parameters for doing this would be to look at differences in the stable isotope composition of water in the pond and in natural groundwater (180 and deuterium). With a clear indication of pond leakage rates, Tronox would be in a better postion to estimate the likely long-term impacts of seepage from the dredge pond using reactive transport modelling.<br>Therefore, the requirement to maintain alkalinity levels has been replaced by the requirement to undertake an investigation into the leakage rates from the dredge pond into the aquifer. |
| Condition 8 | Pg 10 | The Licence Holder must undertake monitoring of the Dredge Pond:<br>a) for the parameters specified in Column 2 of Table 6;<br>b) in the units specified in Column 3 of Table 6; and<br>c) at the frequency specified in Column 4 of Table 6. | Amend Line Item c) to reference "Column 5" as Column 4 refers to the averaging period. | Minor typographical error. | Noted. | Typo has now been corrected. | No comment. | N/A. |
| Condition 8 | 10 | Table 6, Line Items 1 and 2<br>Parameter: pHF and pHFox<br>Averaging period: Spot sample<br>Frequency: Fortnightly | Replace both parameters with a single pH parameter and include 'Monthly' in column 4 to indicate pH readings will be averaged over each month (refer to | pHF and pHFox are soil-based parameters typically associated with Acid Sulphate Soil assessment.<br>To assess compliance against the newly proposed Condition 7 (see above) "Monthly" should be added to column 4. This will allow for the | Noted. | References to soil pH changed to pH; alkalinity added to the parameter list (see above).<br>Monthly added to column 4. | Table 6 should be updated to allow for alkalinity to be measured in the field. | Table changed to allow alkalinity to be determined in the field or laboratory. |

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| | | | comments regarding Condition 7).<br>Proposed amendment:<br>*Parameter: pH*<br>*Averaging period: Spot sample and Monthly*<br>*Frequency: Fortnightly* | calculation of average monthly pH of the dredge pond using the fortnightly pH readings. | | | | |
| Condition 11 | Pg 11 | The Licence Holder must conduct an investigation into the following:<br>a) the extent of potential stratification within the Dredge Pond;<br>b) an assessment of whether the current lime dosing programme is well targeted; and<br>c) the risk of saline and metalliferous water from the Dredge Pond being discharged to groundwater.<br>In addition, the investigation must include, but not be limited to:<br>d) developing and implementing a Sampling and Analysis Plan (SAP) to evaluate the extent of horizontal and vertical heterogeneity across the entire Dredge Pond; and<br>e) developing a detailed monitoring and management plan for the Dredge Pond, based on the outcomes of the sampling and analysis required by Condition 11(d). | Tronox requests the removal of this condition. | Please refer to **Section 3 Condition 11 – ASS Investigations, SAP and Management Plans** for further information pertaining to this item. | This condition can be removed, providing there is a commitment by Tronox to maintain excess alkalinity in the dredge pond (see above). | | Tronox refers to information provided in the previous correspondence, which addressed stratification, lime dosing, saline/metalliferous drainage and SAP. Tronox proposes the listed items be replaced with an assessment to review the role alkalinity plays in dredge pond acidity management. | Refer to comments for condition 7 above. |
| Condition 12 | Pg 11 | The Licence Holder must submit to the CEO, by 1 June 2019, a detailed written report of the outcomes of the investigation required by Condition 11. | Tronox requests the removal of this condition. | Removal of this condition is based on the response to Conditions 11 above. | See above. | | Tronox requests at least 6 months to undertake any required assessments. | Noted. |
| Condition 13 | Pg 11 | Table 7, Line Item 1<br>White tailings, Screen 1/2 oversize, Chandala Mineral Separation Plant (MSP) | Amend Column 1 wording to:<br>• White Tails, Screen 1 and 2 oversize | White tails and Screen 1 and 2 oversize is benign sand containing trace amounts of heavy minerals segregated out at the Chandala Dry Mill. As the heavy mineral content of this material is of potential future value, Tronox stockpile or deposit it outside of the MRF to enable reprocessing at a later date. There is no requirement for this material to be placed in the MRF and as such it can be removed from the list a waste materials approved for disposal at the MRF. However, the ability to receive this material onsite for stockpiling and reprocessing will need to continue. | Noted. | Condition amended as per Tronox request. | No comment. | N/A. |

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| Condition 13 | Pg 11 | Table 7, Line Item 6<br>Pugged waste, Chandala Synthetic Rutile Plant (SRP) | Tronox requests “Pugged waste” and “Liquor pond solids” be separated into two distinct waste products.<br>Amend Characteristic in Column 3 to "Mainly Iron oxide and char" | Pugged waste and liquor pond solids are similar, but are different types of waste, and therefore, they should be listed as two separate items under Waste type in Column 1. Liquor pond slurry is approved for disposal at the MRF under condition S1(b)(iv) of the current Environmental Licence. It is important to note; the use of the word slurry is not an appropriate descriptor of this material and it should be amended to “Liquor Pond Solids”. The material is drained and dried prior to transportation and disposal at the MRF.<br>Tronox requests that Liquid pond solids remain within the licence as it maintains the existing licence approvals. | Noted.<br>N.B. Wastes that do not meet the definition of a ‘solid’ must not be disposed on the Premises. Clause (d) of condition 13 requires all wastes to meet the definition of a ‘solid’. | Condition amended as per Tronox request | No comment. | |
| Condition 13 | Pg 11 | Table 7, Line Item 9<br>Other (hazardous waste) - Chandala MSP & SRP, Kwinana | Amend Waste Type in Column 1 to " Other (Inert and Hazardous waste)"<br>Amend Source in Column 2 to "Chandala MSP & SRP, Kwinana and Cooljarloo"<br>Amend Characteristic in Column 3 to "Material/Equipment from clean up, maintenance, decommissioning and/or construction activities that may have become contaminated by NORM or hydrocarbons" | The amendment provides flexibility to dispose of inert wastes at the MRF.<br>To eliminate potential misinterpretation, Cooljarloo should be included as a potential source site.<br>The characteristic of the "Other (hazardous waste)" has been amended to include material contaminated by hydrocarbons. Tronox requested and received approval from DWER in September 2014 to dispose of hydrocarbon contaminated material. Tronox requests to continue this activity. | Since releasing the draft conditions for Tronox review, DWER has consulted further with DMIRS on this issue, and the following concerns have been raised:<br>1. DMIRS have concerns about non-mining wastes (those generated from Kwinana, i.e. non-mining operations) being disposed at a mining operation. However, the waste appears to be similar enough to the run-of-mine wastes so as to be suitable for disposal in the MRF in this case.<br>2. DMIRS advises that non-mining wastes are typically disposed within waste dumps and not within TSFs, and this activity would have to be assessed and approved under a Mining Proposal. DWER understands Tronox are currently working through these issues with DMIRS, and will need to ensure consistency between approvals.<br>3. The Radiation Management Plan that is currently undergoing review does not support the proposition of disposing plant and equipment that may be contaminated with NORM – the RMP suggests that plant and equipment will be decontaminated and removed by scrap/recycling merchants.<br>4. DWER and DMIRS have not seen anything that suggests the MRF has been designed for disposal of wastes other than run-of-mine wastes. If the original purpose of the MRF has changed over the years, and the profile or safety risk of the MRF has changed with the encapsulation with other materials, Tronox needs to | It is proposed to remove the provision for disposing of ‘other’ non-mining wastes, until it can be demonstrated the MRF is designed appropriate for all the material being encapsulated. | Tronox is pleased the Kwinana waste materials will continue to be accepted at the MRF. Tronox notes the MRF has been in operation for many years and has been classified and licenced as a Class III Landfill for the purposes of servicing the Tronox operations. The MRF has been assessed and approved by DWER to accept the wastes listed in the current licence, which includes non-mining waste and inert waste.<br>The comments suggesting the facility has not been designed appropriately for other/non-mining waste are unexpected, considering the DWER assessed and approved the most recent expansion in 2014. DWER has had full regulatory control over the Class III Landfill for many years and Tronox has continued to operate and report on the facility in accordance with the Licence conditions. There has been no change to the MRF or it's purpose. The change which has occurred sits firmly with the DWER which has changed it's classification and requirements pertaining to the facility. Tronox is committed to working with DWER to work through the Departments changes, however Tronox request DWER be cognisant of the operational impacts any change to the facility's operation may have on the Business.<br>Tronox disagrees with the statement that the Radiation Management Plan doesn't support the disposal of plant/equipment contaminated with NORM at the MRF. The RMP states that if | DWER will be guided by DMIRS in terms of the actual classification of the facility and needs to ensure that any approval granted under the EP Act is consistent with DMIRS guidelines, especially as the site transitions onto Mining Act tenement. For all intents and purposes of the licence and the proposed Cell 8 extension, in the absence of a Mining Proposal and approvals under the Mining Act, DWER needs to ensure the facility is constructed and operated to relevant standards, i.e. relevant sections of the DMIRS TSF COP, and is fit for purpose in terms of being a safe stable landform that manages safety and environmental risks. Once the site comes onto Mining Act tenement, the main regulatory oversight of the facility from a safety perspective will come across to the Mining Act, e.g. through regular detailed reviews of TSF design, construction and audit reports, etc.<br>As previously mentioned, the disposal of non-mining wastes is not typical therefore Tronox needs to demonstrate how the liner system addresses all the safety risks (i.e. from a health and contamination of groundwater) for all material in the facility. |

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| | | | | | demonstrate the MRF is designed appropriate for all the other materials being encapsulated, such as demonstrating how all the liner systems address all the safety risks (i.e. from a health and contamination of groundwater) for all material in the MRF landform and all planned material to be placed on the MRF landform. | | plant/equipment is to be recycled, it shall be decontaminated prior to removal by a third party recycler. This requirement is to ensure potentially contaminated material isn't sent to facilities without the appropriate controls in place. The MRF is a controlled and regulated facility designed to accept materials containing NORM.<br>Tronox requests the revised licence allows for the continued disposal of non-mining and inert wastes as per the existing licence. | |
| Condition 15 | Pg 12 | The Licence Holder must ensure that dust from the Black Waste Dump is not visible outside of the Black Waste Dump area, as shown in Figure 2 of Schedule 1. | Amend condition to:<br>*The Licence Holder must ensure that dust from the Mineral Residue Facility is not visible crossing the MRF Dust Management Area boundary as shown in Figure 2 of Schedule 1.* | Tronox consider this condition to be overly conservative and proposes the implementation of an MRF Dust Management Area which consists of a 100m buffer on all sides of the approved and proposed cells, except for adjacent to the Mullering Brook (refer to Attachment 1). | DWER's justification for this control is clearly set out in section 8.9 of the Decision Report.<br>The risk of allowing dust fallout within 100 metres of the BWD is not acceptable. | No changes proposed. | Tronox acknowledge there is evidence of dust fallout outside of the MRF boundary, and that under certain weather conditions (high winds/hot temperatures) there is potential for dust fallout to occur outside the boundary even with the prescribed controls being implemented. In order to assess the environmental impacts of these events, Tronox undertake surface water monitoring and radiation surveys. To date, results have not indicated NORM/metals contamination outside the MRF associated with dust fallout.<br>Tronox is committed to controlling windblown dust from the MRF, but feel the proposed licence condition is far too conservative and does not consider the actual risk associated with small volumes of wind blown dust escaping the MRF on an infrequent basis. Taking a risk-based approach, considering the established monitoring program and results to date, Tronox finds this condition to be inappropriate. | DWER reiterates that its justification for this control is clearly set out in section 8.9 of the Decision Report. |
| Condition 16 | Pg 12 | Table 8, Dot Point 3<br>Active dust suppression:<br>• If mobile watering measures have not prevented dust liftoff and there is a risk of dust escaping the Black Waste Dump area, fixed sprinkler systems, mobile windbreaks or both are to be employed to reduce wind effects | Tronox requests the removal of this condition. | Tronox consider that windblown material from the MRF is a low risk and that Points 1 and 2 under "Active Dust Suppression in Table 8 are adequate. The dumping location on the MRF moves along the active face, progressively filling the area. Fixed sprinklers will not be able to be moved with the working face of the MRF.<br>There are three tiered dumping locations on the MRF and these face the predominant wind direction, as such mobile windbreaks are unlikely to be effective at blocking the wind and could be dangerous given the steep angle of the face. Dust monitoring are Dust Gauge 09, | DWER does not agree that current dust management practices are adequate to mitigate dust lift-off during high wind conditions, as evidenced by the amount of windblown material on the south side and roads exiting the facility. Additional controls are therefore warranted to ensure dust is minimised and the material does not escape the facility.<br>DWER has not at any stage endorsed dust level criteria at this site and therefore internal monitoring results – from only 2 dust gauges in the vicinity of the BWD - cannot be used to justify performance. In addition the amount | If the controls suggested by DWER are not practicable, alternatives put forward by Tronox will be considered for possible inclusion in the Revised Licence. | Accepted. | Nil. |

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| | | | | located on top of the MRF, has not recorded any exceedances for 10 years, as a result of implementing the management practice of applying of clay slimes on open areas.<br>The continued implementation of current dust management practises and monitoring is considered to provide adequate risk mitigation. | of windblown material outside of the facility does not support the claim of "no exceedances". | | | |
| Condition 16 | | Table 8, Dot Point 4<br>Stabilisation:<br>• Active waste pits to be sheeted with overburden (or similar) to minimise the area of waste exposed | Tronox requests the removal of this condition. | Overburden is only placed over the MRF as capping (Line 7 of Table 8) once final landform design is reached. Non active dumping areas of the MRF are sprayed with clay fines to stabilise the material whilst not in use. This practice is deemed to be successful based on the monitoring results of Dust Gauge 09, located on top of the MRF, which has not recorded any exceedances for 10 years, since the introduction of the application of clay slimes on open areas. | Noted. | The requirement to use overburden has now been replaced by the application of clay slimes on open areas. | Tronox confirms the application of clay fines is undertaken only on non-active areas. It is proposed this condition be made clearer by changing 'active waste pits' to 'non-active dumping areas'. | Condition amended as per Tronox request. |
| Condition 16 | | Table 8, Dot Point 6<br>Covering/capping<br>• Each load of coarse rejects must be covered as soon as practicable, but no later than 30 minutes, after deposition | Amend condition to:<br>*Covering/capping*<br>*• Each load of coarse rejects must be covered as soon as practicable, but no later than 4 hours, after deposition* | The requirement to cover the material within 30 minutes of deposition is not operationally feasible. As such, Tronox request the condition be amended to an operationally achievable time period. | DWER requests further information on why covering within 30 minutes is not feasible. | | Tronox refers DWER to the Industry Regulation Fact Sheet - Mineral sands mining and processing (DWER 2018). The fact sheet specifically states: 'The management of radiological risks from NORM is undertaken jointly by the DMIRS and RCWA. DWER defers the management of risks from NORM to these government agencies.'<br>Tronox has an approved Radiation Management Plan endorsed by DMIRS. Considering the position detailed in the DWER Fact Sheet and the site having an endorsed RMP, Tronox requests this condition be removed to reflect DWER's documented position regarding the deferral of management of NORM to DMIRS/RCWA.<br>Stipulating coarse rejects must be covered within 30 mins of dumping requires additional heavy mobile equipment and personnel. The additional operational costs associated with fulfilling this condition is not reasonable given the low level risk posed by the disposal of the relatively small volumes of coarse rejects at the MRF (10% of annual total). In accordance with the RMP, regular radiation monitoring is undertaken at, and surrounding, the MRF to ensure NORM is being managed appropriately. | NORM is one of two considerations – potential impacts from inorganic hazards is the other. The requirement to cover the deposited material to minimise the risk of dust lift-off is therefore considered to be appropriate.<br>The time specification has been removed from the condition, however the onus is on Tronox to demonstrate that its covering frequency is sufficient to minimise the risk of dust lift-off during high wind conditions. |
| Condition 17 | Pg 12 & 13 | Table 9, Column 1<br>BWD monitoring bores:<br>WMB01A, WMB02C, WMB06sB, WMB07S, | Tronox request Column 1 be amended to:<br>*BWD monitoring bores: WMB01A, WMB02C,* | Tronox requests the bores be amended to align with the Groundwater Operating Strategy (GOS), remove the bores which are | Noted.<br>N.B. This condition is subject to change, pending the outcome of ongoing Contaminated Sites | Condition amended as per Tronox request. | No comment. | N/A. |

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| | | WMB08b, WMB09, WMB11S & D, WMB12S & D, WMB13 WMB14 | *WMB06sB, WMB07d, WMB09, WMB11d, WMB12d, WMB13, WMB15 and WMB16.* | not accessible/operational and include two new bores installed west of the MRF.<br>Remove WMB07S – WMB07d is in the same location and is suitable for assessing water quality in this area.<br>Remove WMB08b – This bore is blocked and is not included in the GOS. WMB07d is the closest bore to this location and is suitable for assessing water quality in this area.<br>Remove WMB11s – Not in use, WMB11d is in the same location and is suitable for assessing water quality in this area.<br>Remove WMB12s – Not in use, WMB12d is in the same location and is suitable for assessing water quality in this area.<br>Remove WMB14 – Not in use due to blockage. WMB07d is the closest bore to this location and is suitable for assessing water quality in this area.<br>Add WMB15 & 16 – Newly installed bores located west of the MRF. These bores will help to identify any potential groundwater quality impacts down hydraulic gradient of the MRF. | investigations. | | | |
| Condition 18 | Pg 13 | Table 10, Column 1<br>DG01, DG05, DG06, DG07, DG08, DG11, DG 13, DG14 | Amend the list of dust gauges to include DG07 and DG09 only. | The intent of this condition is to require the monitoring of dust within the vicinity of the MRF. DG09 is located on the MRF and DG07 is ≈1km northwest of the MRF. However, the remaining dust gauges are >1km from the MRF, are unlikely to capture any material associated with the landform, and therefore, Tronox consider that they are not required to monitor elevated dust around the MRF. | DWER considers additional dust monitoring locations are required on, and in the vicinity of, the BWD, in order to more adequately and accurately capture the level of dust being generated. | It is suggested Tronox propose a more rigorous dust monitoring program for the BWD for DWER's consideration. | Four directional depositional dust gauges will be installed around the active cell to evaluate wind blown dust from the MRF. | Added to the revised licence. DWER reiterates the siting must be in accordance with AS 2922-1987. |
| Condition 18 | Pg 13 | Table 10, Column 4<br>Monthly, between1 October and 31 May inclusive | Amend the monitoring frequency to Quarterly | Tronox consider the dust poses a low risk and monitoring on a quarterly basis is adequate to determine the effectiveness of control measures.<br>There are no sensitive receptors within close proximity to the site and no evidence to indicate flora impacts as a result of smothering. | As discussed above, in considering the amount of windblown material on the south side and roads exiting the facility, DWER would argue there is insufficient information to determine a low risk rating, and that monitoring on a monthly basis is warranted until such time DWER considers there to be sufficient information to make an informed determination on the risk. | No changes proposed. | Accepted. | Nil. |
| Condition 19 | Pg 14 | The Licence Holder must maintain accurate records of:<br>(b) any blending of waste types that occur; and | Tronox requests the removal of this condition. | Blending and mixing of the waste types listed in Table 7 occurs as a result of loading and transport, as well as placement and land forming within the MRF. As all waste materials will be blended or mixed to some degree, Tronox is unclear as to what records would be maintained under this condition, and what the records would be used for. | As there are a number of waste materials generated by the integrated operation and at different times, DWER considers this information will better inform the regulators when and for what purpose the different waste types are being blended and/or mixed. | No changes proposed. | As previously stated, the different waste types for mix together during temporary storage, loading, transport and disposal. No specific blending is undertaken. As such, if this condition remains, no records will be maintained as "blending" doesn't occur. If DWER classify the mixing which occurs during storage, loading, transport and disposal, as blending than Tronox will report that all material is blended together. | This requirement has been removed. |

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| | | | | | | | It is reiterated that Tronox does not understand the intent of this condition, nor how to fulfil the requirements of it. More detail is requested from DWER to assist Tronox regarding this matter. | |
| Condition 21 | Pg 21 | The Licence Holder must ensure the report required by Condition 19 includes an assessment and trend analysis of the results against previous monitoring results and relevant environmental standards. | Amend condition to "*...required by Condition 20 includes an assessment...*" | Minor error - Reporting is referred to in Condition 20, not Condition 19. | Noted. | Typo has now been corrected. | No comment. | N/A. |
| Condition 22 | Pg 14 | Table 11, Column 1<br>Aspect:<br>• Drilling<br>• Overburden<br>• Oversize (ore)<br>• Clay fines<br>• Sand tailings | Amend aspects in Column 1 to:<br>*Aspect:*<br>• *Drilling ASS Overburden,*<br>• ASS Oversize (ore)<br>• *ASS Clay Fines*<br>• *ASS Sand Tailings* | The changes clarify that the Actions/Requirements in Column 2 are only applicable to actual and/or potentially acidic material and not all material on site. | DWER considers the table already specifies where actions/requirements only apply to AASS/PASS – otherwise the requirements apply to all material on the site (unless it can be demonstrated where it should not apply). | No changes proposed. | Accepted. | Nil. |
| Condition 22 | Pg 14 | Table 11, Column 2, Dot Point 1<br>Drilling:<br>• Testing for pHF and pHFOX must be conducted during all mine drilling – at least 1 in every 15 drill holes (≥0.2 holes/ha) | Amend condition to:<br>*Drilling:*<br>• *Testing for pHF and pHFOX must be conducted during pre mine drilling (≥0.2 holes/ha)* | Tronox recognise that specifying 1 in every 15 drill holes may not meet the ≥0.2 holes/ha as it depends on the stage / scale of drilling. For example, if a 20 m × 50 m drilling program is used then there are around 10 drill holes / ha or 50 holes / 5 ha. If 1 in every 15 drill holes need to be tested for ASS then this equates to 0.7 drill holes / ha. But if a coarser drill program is used, such as 50 m × 100 m spacing then there is only 20 drill holes / 10 ha, which only equates to an ASS testing density of 0.1 holes/ha. To avoid this potential inconsistency, it would be better to only specify pre-mine ASS testing of ≥ 0.2 holes/ha, and remove the 1 in 15 drill holes. | Noted. | Condition amended as per Tronox request. | No comment. | N/A. |
| Condition 22 | Pg 14 | Table 11, Column 2, Dot Point 2<br>Overburden:<br>• Daily field surveys (pHF and pHFOX) must be conducted during removal of overburden containing PASS or in areas where there are indicators of PASS | Tronox requests the removal of this condition. | Tronox conducts ASS sampling during pre-mining drilling at a spatial scale sufficient to accurately identify actual and/or potentially acidic overburden. The sample results, together with drilling logs, are utilised to model the volume and location of the acidic overburden and inform management options. As such, Tronox do not consider that any further sampling is required. | The removal of this condition would leave DWER with no means of assessing whether overburden has been adequately assessed for the presence of pyrite. | As Tronox is required to be accountable for managing overburden that contains pyrite, the following is proposed:<br>*Overburden:*<br>• *Prior to overburden removal, the presence of pyrite and pyrite-oxidation products in overburden must be identified by appropriate field investigations and by referral to the conceptual geological model for the Premises; and*<br>• *Details of sites where pyrite or its oxidation products have been shown to be present in overburden must be recorded, in addition to* | Accepted. | Nil. |

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| | | | | | | *information on how the material has been managed to prevent its acidification.*<br>The 'conceptual geological model' refers to the work by Soilwater to identify the geological factors that control the distribution of sulphide minerals in sediments at the Premises. The conceptual geological model should also be periodically reviewed based on new information obtained during ongoing field investigations at the Premises. | | |
| Condition 22 | Pg 14 | Table 11, Column 2, Dot Point 3<br>Overburden:<br>• Reactive overburden must be treated with lime at a minimum rate of 5 kg/t CaCO3 and buried at least 10 m below surface | Amend condition to:<br>*ASS Overburden:*<br>*• Actual and/or potentially acidic overburden must be: ○ buried (untreated) at the base of a slimes dam, at least ≥1m above water table, or*<br>*○ completely below the water table (PASS material), or*<br>*○ treated at the calculated liming rate (PASS/AASS)* | The proposed amendment provides a number of potential management options which are commensurate to the risk to the environment and to provide more operational flexibility. The appropriateness of each Action/Requirement is discussed below:<br>1. Untreated overburden can be utilised to form the base of a slimes dams, ≥1m above the water table, as the risk of oxidation or release / mobilisation of oxidation products is negated, due to the overlying clay fines and underlying tailings.<br>2. The placement of potentially acidic overburden below the water table limits the risk of oxidation.<br>3. The reactivity of overburden will vary and thus the liming rate should be calculated from the known acidity values of the material to ensure the appropriate rate of lime is applied to effectively neutralise the material. The appropriate treatment of actual and/or potentially acidic overburden will result in sufficient alkalinity being present in the material to neutralise any actual or potential acidity (with a sufficient safety factor included), and thus the treated overburden can be used at any point in the rehabilitated profile. | Noted. | Condition amended as per Tronox request. | No comment. | N/A. |
| Condition 22 | Pg 14 | Table 11, Column 2, Dot Point 4<br>Overburden:<br>• Reactive overburden/oversize requiring stockpiling prior to treatment and burial must be stockpiled on a treatment pad comprising minimum 300 mm thick compacted crushed limestone (or other appropriate neutralisation material) and bunded with a minimum 150 mm | Amend condition to:<br>*ASS Overburden:*<br>*• Actual or potentially acidic overburden requiring stockpiling prior to treatment and burial must be stockpiled on a treatment pad comprising minimum 300 mm thick compacted crushed limestone (or other appropriate neutralisation material) and bunded with a minimum 150 mm high perimeter of compacted, crushed limestone (or* | The minor amendment to the condition is to allow stockpiling and treatment of ASS overburden on a clay lined pad. Agriculture lime can be spread over the based of the clay pad to provide neutralisation capacity for any potential leachate. | Noted. | Condition amended as per Tronox request. | No comment. | N/A. |

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| | | high perimeter of compacted, crushed limestone to contain leachate runoff within the treatment pad area/prevent surface water runoff from entering the pad area | *impermeable material) to contain leachate runoff within the treatment pad area/prevent surface water runoff from entering the pad area.* | | | | | |
| Condition 22 | Pg 14 | Table 11, Column 2, Dot Point 7 and 8<br>Clay fines:<br>• TA, Total Potential Acidity (TPA) and TAlk of clay fines within solar drying ponds must be monitored at least fortnightly during plant operation;<br>• TA, TPA and TAlk of dried clay fines must be determined prior to landform reconstruction | Replace TA with TAA. | Minor error - the acronym for TA is not included in Table 1: Definitions. It is assumed that this is meant to be TTA instead. | Noted. | References to TA replaced with TTA. | The following amended condition is proposed:<br>Total Titratable Acidity (TTA), Total Potential Acidity (TPA) and TAlk of clay fines must be monitored at least fortnightly whilst pumping to Solar Drying Dams. | Condition amended as per Tronox request. |
| Condition 22 | Pg 14 | Table 11, Column 2, Dot Point 9<br>Clay fines:<br>• Clay fines must be treated with lime at a minimum rate of 5 kg/t $CaCO_3$ if deposited above the water table | Amend condition to<br>*ASS Clay fines:*<br>*• Management of actual and potentially acidic clay fines will involve: ○ untreated clay fines placed as a homogenous layer >1m above the water table,*<br>*○ placement of PASS clay fines completely below the water table, or*<br>*○ treatment at the calculated liming rate (PASS/AASS)* | Clay fines have a particle size of <63µm and when placed as a homogenous layer, such as in a slimes dam, they form a solid layer with a seepage rate of 3.7 x 10-10 m/s, less than the 10-9 m/s required by DWER for Clay liners for landfill sites. The characteristics of the layer limit oxygen diffusion into the clay and thus the reaction of the sulphides. If this material is placed at depth, as it is in the dredge pond and at the base of voids during drying mining, the depth and saturation of the material limit the oxygen and reaction. Modelling has shown that the acidic clay fines, even when not placed above the water table, as a homogenous layer will result in minimal seepage into the environment (SWC, 2018).<br>The clay fines are fully saturated when pumped to the solar drying dams. Any sulphides within the material remain in a reduced condition, and therefore, are considered as Potential Acid Sulphate Soils (PASS). Oxidation of the top portion of the clay fines does occur. However, it is limited to the top portion of the clay as shown in SWC (2018) due to the extent to which oxygen can penetrate the material once dried and the lack of water to facilitate the reaction. As such, liming of this material is not required, as the risk posed to the environment is low. Groundwater monitoring has not detected leachate from the solar drying dams. Groundwater monitoring will continue in accordance with condition 26 to confirm the management measure are adequate. The AASS or PASS concentration of the clay fines will vary and thus the | Noted. | Condition amended as per Tronox request. | Minor changed to reduce potential misinterpretation:<br>ASS Clay fines:<br>• Management of actual and potentially acidic clay fines will involve: o untreated clay fines placed as a homogenous layer >1m above the water table *in Solar Drying Dam*s, or | Condition amended as per Tronox request. |

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| | | | | liming rate should be calculated from the known acidity values of the material to ensure the appropriate rate of lime is applied to effectively neutralise the material. Once appropriately treated, the actual and/or potentially acidic clay fines will have sufficient alkalinity to neutralise any actual or potential acidity (with a sufficient safety factor included), and thus the treated clay fines can be used at any point in the rehabilitated profile. | | | | |
| Condition 22 | Pg 14 | Table 11, Column 2, Dot Point 10<br>Sand tailings:<br>• Must be deposited at the base of the Dredge Pond | Tronox requests the removal of this condition. | Sand tailings present a low risk to the environment as outlined in Table 15 of the decision report, and as such, Tronox do not consider that the specific placement of the material warrants conditioning. A minimal amount of acidic clay may be trapped within the sand tailings when its pumped ex-pit, which will pose a low risk to the environment. This is supported by groundwater monitoring not detecting leachate from the solar drying dams. | Noted. | Reference has been removed as it duplicates the tailings disposal requirements listed in Table 2, Line Item 1. | No comment. | N/A. |
| Condition 23 | Pg 15 | Table 12, Column 2, Dot Point 3<br>Stockpiles:<br>• Must minimise the number and size of stockpiles | Tronox requests the removal of this condition. | Tronox do not consider this condition is required. The risk posed by stockpiled HMC is low as outlined in Table 15 of the decision report. The height of a HMC stockpile is limited by the stacker, and the number of stockpiles is limited by the size of the HMC pad.<br>This condition is general in nature and compliance against it would be difficult to establish. | Noted. | This requirement has now been removed. | No comment. | N/A. |
| Condition 23 | Pg 15 | Table 12, Column 2, Dot Point 4<br>Stockpiles<br>• Must maintain moisture content of ≥ 5 % during wet stacking of HMC | Tronox requests the removal of this condition. | The risk posed by stockpiled HMC is low as outlined in Table 15 of the decision report. In addition, it's in Tronox's interest to ensure the HMC is stored in a manner to prevent windblown losses give the high value nature of the product. The inclusion of a specific moisture content value is not considered appropriate, particularly without valid justification for the chosen value. | Noted. | This requirement has now been removed. | No comment. | N/A. |
| Condition 23 | Pg 15 | Table 12, Column 2, Dot Point 8<br>Monitoring<br>• Must be conducted monthly during the period October – May | Amend to "Must be conducted *quarterly*" | Refer to comments on condition 18(d) | Monthly collection and analysis of samples is consistent with AS3580.10.1, i.e. every 30 days ± 2 days. This is to ensure accurate capture of data as g/m$^2$/month.<br>Tronox may elect to monitor all year round, however the focus of DWER is dust levels during the drier months, i.e. Oct – May. | No changed proposed. | Accepted. | Nil. |
| Condition 26 | Pg 15 & 16 | Table 13, Column 1<br>Monitoring point and reference location:<br>GDV observation:<br>DGP01, MSB04, NBF09S, NVMB03S, NVMB04S, NVMB15, OB32 | Amend condition to:<br>*Monitoring point and reference location:*<br>• the dredge pond,<br>• two nested bores upgradient of the active dredge pond | The inclusion of specific bores may result in compliance issues when they are required to be removed as the mine void progresses throughout the life of mine. In addition, referring to locations in relation to the active dredge pond (upgradient, downgradient, pre and post) will provide flexibility to move the | Noted. | Condition amended as per Tronox request. | No comment. | N/A. |

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| | | Pre and Post mining observation bores: MBS13, MSB03, MSB05, MSB07, MSB10d, NAMD01, NAMD02, OB07, OB14, OB15d, OB18d, OB20s/d, OB23s/d, OB28 | • *two nested bores downgradient of the active dredge pond*<br>• *two nested bores downgradient of future mine path (> 6 months ahead),*<br>• *two nested bores up gradient of future mine path (>6 months ahead),*<br>• *two nested bores downgradient of mined areas (until within pre-mining levels),*<br>• *two nested bores up gradient of mined areas (until within pre-mining levels),* | monitoring focus as the operations progress. This will also allow for the recording of water quality and levels in the post mining environment. Bores within the Falcon area (Groundwater area D) have not been included as the groundwater quality and levels have returned to within the premining range as outlined in the Triennial Aquifer Review (HGEO, 2019) (Attachment 3). | | | | |

# Appendix 3: Biological component

| **Threatened / Priority Flora** | |
|---|---|
| A total of 34 DRF and priority flora species were recorded within and/or in the vicinity of the Premises between 2005 and 2009 as part of vegetation surveys for the Cooljarloo West proposal.<br>A number of poorly known taxa and range extensions have also been recorded within and/or in the vicinity of the Premises. | |
| - *Acacia benthamii* (P1)<br>- *Andersonia gracilis* (DRF)<br>- *Angianthus micropodioides* (P3)<br>- *Anigozanthos humilis* subsp. *Chrysanthus* (P4)<br>- *Anigozanthos viridis* subsp. *terraspectans* (DRF)<br>- *Arnocrinum gracillum* (P2)<br>- *Baeckea* sp. Perth Region (R.J. Cranfield 444) (P3)<br>- *Banksia dallanneyi* subsp. *Pollosta* (P3)<br>- *Banksia platycarpa* (P4)<br>- *Beaufortia bicolor* (P3)<br>- *Beaufortia eriocephala* (P3)<br>- *Calectasia palustris* (P1)<br>- *Chordifex chaunocoleus* (P4)<br>- *Chordifex reseminans* (P1)<br>- *Conostephium magnum* (P4)<br>- *Conospermum scaposum* (P3)<br>- *Desmocladus biformis* (P3)<br>- *Eremophila glabra* subsp. chlorella (DRF)<br>- *Eryngium pinnatifidum* subsp. *palustre* (P3)<br>- *Eucalyptus johnsoniana* (DRF)<br>- *Frankenia glomerata* (P3)<br>- *Grevillea thelemanniana* subsp. Cooljarloo (B.J.<br>Keighery 28B) (P1)<br>- *Goodenia ?trichophylla* (P3)<br>- *Haloragis foliosa* (P3)<br>- *Hensmania stoniella* (P3)<br>- *Hibbertia helianthemoides* (P3)<br>- *Hypocalymma serrulatum* (P3)<br>- *Hypocalymma tetrapterum* (P3)<br>- *Isopogon* sp. Badgingarra (A.S. George 14200) (P2)<br>- *Jacksonia carduacea* (P3)<br>- *Lasiopetalum lineare* (P3)<br>- *Lepidobolus densus* ms (P3)<br>- *Leucopogon* sp. Yanchep (M. Hislop 1986) (P3)<br>- *Loxocarya gigas* (P2)*Lyginia excelsa* (P1)<br>- *Macarthuria keigheryi* (DRF)<br>- *Melaleuca clavifolia* (P1)<br>- *Meionectes tenuifolia* (P3)<br>- *Onychosepalum microcarpum* (P1)<br>- *Onychosepalum nodatum* (P3)<br>- *Platysace ramosissima* (P3) | - *Schoenus griffinianus* (P3)<br>- *Schoenus natans* (P4)<br>- *Schoenus pennisetis* (P1)<br>- *Stenanthemum sublineare* (P2)<br>- *Stylidium hymenocraspedum* (P2)<br>- *Stylidium aceratum* (P2)<br>- *Stylidium longitubum* (P3)<br>- *Thysanotus glaucus* (P4)<br>- *Verticordia amphigia* (P3)<br>- *Verticordia lindleyi* subsp. *lindleyi* (P4)<br>- *Villarsia submerse* (P4) |

| **Threatened / Priority Fauna** | |
|---|---|
| A total of 18 fauna species of conservation significance have been recorded within and/or in the vicinity of the Premises as part of terrestrial fauna studies since 1986<br>Three levels of Conservation Significance (CS) are recognised:<br>- CS1: Species listed under State and/or Commonwealth Acts;<br>- CS2: Species listed as Priority species by DPaW; and<br>- CS3: Species of local significance because of their pattern of distribution. | |
| *Fish*<br>- Western Minnow *Galaxias occidentalis* (CS3)<br>- Pygmy Perch *Edelia vittata* (CS3)<br>*Frogs*<br>- Squelching Froglet *Crinia insignifera* (CS3)<br>*Reptiles*<br>- South West Carpet Python *Morelia spilota imbricata* (CS1: Sch 4; CS2: P4)<br>- Woma *Aspidites ramsayi* (CS1: Sch 4; CS2: P1)<br>- Black-striped Snake *Neelaps calonotos* (CS2: P3)<br>- Jewelled Ctenotus *Ctenotus gemmula* (CS2: P3)<br>- Speckled Stone Gecko *Diplodactylus polyophthalmus* (CS3)<br>- Tiger Snake *Notechis scutatus* (CS3)<br>- Bold-striped Lerista *Lerista christinae* (CS3)<br>- Legless Lizard *Aprasia* sp. nov. aff. '*fusca*' (CS3)<br>*Birds*<br>- Carnaby's Black-Cockatoo *Calyptorhynchus latirostris* (CS1: End, Sch 1)<br>- Peregrine Falcon *Falco peregrinus* (CS1: Sch 4)<br>- Fork-tailed Swift *Apus pacificus* (CS1: MIG, JAMBA, CAMBA) | - Rainbow Bee-eater *Merops ornatus* (CS1: MIG, JAMBA, CAMBA)<br>- Migratory waterbirds (CS1: MIG, JAMBA, CAMBA)<br>- Western Ground Parrot *Pezoropus walliculs flaviventris* (CS1: End, Sch 1)<br>- Australian Bustard *Ardeotis australis* (CS2: P4)<br>- Rufous Fieldwren *Calamanthus campestris montanellus* (CS2: P4)<br>- Crested Bellbird *Oreoica gutturalis gutturalis* (CS2: P4)<br>- Square-tailed Kite *Lophoictinia isura* (CS3)<br>- Southern Emu-wren *Stipiturus malachurus* (CS3)<br>- Scarlet Robin *Petroica multicolor* (CS3)<br>- White-breasted Robin *Eopsaltria georgiana* (CS3)<br>*Mammals*<br>- Brush Wallaby *Macropus Irma* (CS2: P4)<br>- Quenda *Isoodon obesulus* (CS2: P5)<br>- Tammar *Macropus eugenii* (CS2: P5)<br>- Brushtail Possum *Trichosurus Vulpecula* (CS3)<br>- Western Freetail Bat *Mormopterus* sp. 4, Population O (CS3) |

ICUN categories as used for the EPBC Act and the *Wildlife Conservation Act 1950:*

| **Category** | **Definition** |
|---|---|
| Extinct | Taxa not definitely located in the wild during the past 50 years |
| Extinct in the Wild | Taxa known to survive only in captivity |
| Critically Endangered | Taxa facing an extremely high risk of extinction in the wild in the immediate future |
| Endangered | Taxa facing a very high risk of extinction in the wild in the near future |
| Vulnerable | Taxa facing a high risk of extinction in the wild in the medium-term future |
| Near Threatened | Taxa that risk becoming Vulnerable in the wild |
| Conservation Dependent | Taxa whose survival depends upon ongoing conservation measures, which without a conservation dependent taxon would be classed Vulnerable or more severely threatened |
| Data Deficient (Insufficiently Known) | Taxa suspected of being Rare, Vulnerable or Endangered, but whose true status cannot be determined without more information |
| Least Concern | Taxa that are not Threatened |

Schedules used in the *Wildlife Conservation Act 1950*:

| Schedule | Definition |
|---|---|
| Schedule 1 | Rare and likely to become Extinct |
| Schedule 2 | Extinct |
| Schedule 3 | Migratory species listed under international treaties |
| Schedule 4 | Other specially protected fauna |

DBCA Priority species (species not listed under the *Wildlife Conservation Act 1950*, but for which there is some concern):

| Priority | Definition |
|---|---|
| Priority 1 | Taxa with few, poorly known populations on threatened lands |
| Priority 2 | Taxa with few, poorly known populations on conservation lands; or taxa with several, poorly known populations not on conservation land |
| Priority 3 | Taxa with several, poorly known populations, some on conservations lands |
| Priority 4 | Taxa in need of monitoring. Taxa which are considered to have been adequately surveyed, or for which sufficient knowledge is available, and which are considered not currently threatened or in need of special protection, but could be if present circumstances change |
| Priority 5 | Taxa in need of monitoring. Taxa which are not considered threatened but are subject to a specific conservation program, the cessation of which would result in the species becoming threatened within five years (IUCN Conservation Dependent). |

# Attachment 1: Amended Licence L5319