YALYALUP
Mineral Sands Project

EP ACT
SUPPORTING DOCUMENT

Version 1 – October 2017

Prepared by:

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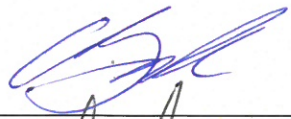
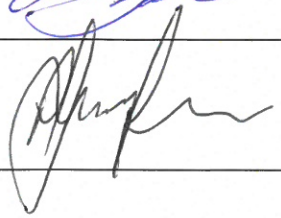
Craig Bovell (HS&E Superintendent) Doral Mineral Sands Pty Ltd	Reviewer		25-Oct-17
Andrew Templeman (General Manager) Doral Mineral Sands Pty Ltd	Authorised Delegate		25-Oct-17

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1. INTRODUCTION

1.1. PURPOSE AND SCOPE

Doral Mineral Sands Pty Ltd (Doral) proposes to extract ore from the Yalyalup Mineral Sands Deposit (i.e. the Proposal), which is located ~11km southeast of Busselton, WA (Figure 1-1). The Proposal is within an area Doral have been granted Retention Licence R70/0052, which covers an area of approximately 2,290 hectares.

Approximately 12-16 million tonnes (t) will be extracted from the deposit to produce ~500-700,000t of heavy mineral concentrate (HMC). The HMC product to be generated from mining the deposit includes zircon, ilmenite, leucoxene and rutile. HMC will be trucked to the existing Picton processing plant. The life of mine is expected to be ~4.5 to 5.5 years. Rehabilitation and mine closure will be implemented at the cessation of mining, which is likely to take up to five years.

The Proposal has a total disturbance area of ~372.67ha within a Development Envelope of 894.17ha. The proposed mine pits have a disturbance area of ~334.32ha and associated infrastructure has a disturbance of ~38.35ha. The majority of the disturbance area (~371ha) is located on previously cleared farmland currently used for beef cattle, dairy cattle and pasture, with the remaining ~1.67ha occurring within degraded native vegetation The City of Busselton's Town Planning Scheme (TPS) No. 21 (TPS 21) shows the Development Envelope as being zoned as 'Agriculture'.

Doral now seek to refer this Proposal to the Environmental Protection Authority (EPA) under Section 38 of the *Environmental Protection Act 1986* (EP Act), as the Proposal is likely to have a significant effect on some aspects of the environment. This Environmental Review Document (ERD) has been prepared as a supplementary report (Part B) to the Referral Form (Part A) and aims to provide sufficient information about the environmental impacts of the Proposal and the proposed application of the mitigation hierarchy to avoid, minimise, rehabilitate (and offset, if appropriate) those impacts. The ERD has been prepared in accordance with *Environmental Impact Assessment (Part IV Divisions 1 and 2) Procedures Manual* (EPA, 2016a) and generally follows the *Instructions and Template: Environmental Review Document* for an ERD.

1.2. PROPONENT

Doral is a wholly owned subsidiary of Perth-based Doral Proprietary Limited, which itself is an unlisted public company owned by Iwatani International Corporation of Japan.

The registered office for Doral is:

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1.3. ENVIRONMENTAL IMPACT ASSESSMENT PROCESS

Doral is referring the Proposal under Section 38 of the EP Act.

1.4. OTHER APPROVALS AND REGULATIONS

The Proposal has the potential to affect Matters of National Environmental Significance (MNES) protected under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The EPBC Act provides that actions that have or are likely to have a significant impact on MNES require approval from the Commonwealth Minister for the Environment. The Proposal will be referred to the Commonwealth Department of the Environment and Energy (DoEE) for consideration under the EPBC Act in parallel with this referral.

Should the DoEE determine that the Proposal is a controlled action and requires assessment and decision on approval under the EPBC Act, it is Doral's preferred position that the Proposal is assessed under the intergovernmental bilateral agreement between the Commonwealth of Australia and the State of Western Australia under Section 47 of the EPBC Act. The bilateral agreement allows the Commonwealth Minister for the Environment to rely on the State EIA process in assessing this action under the EPBC Act so long as the State process considers and addresses those matters protected under the EPBC Act.

Following the State/Commonwealth Environmental Impact Assessment (EIA) process, the Proposal is required to gain environmental approval under the following State Acts, prior to it proceeding:

- *Mining Act 1978;*
- Part V of the EP Act;
- *Rights in Water and Irrigation Act 1914* (RIWI Act).

2. THE PROPOSAL

2.1. JUSTIFICATION

Doral is a global supplier of the products of mineral sands mining (ilmenite, leucoxene, rutile and zircon). Continuation of mining is core to Doral's business and crucial to continue to deliver to a global market.

Doral have operated in the southwest region of Western Australia since 2002, from one previously operating mine (Dardanup Mine) which extracted ore from the Dardanup and Burekup Mineral Sands Deposits, located approximately 20km east of Bunbury. Operations ceased at the Dardanup Mine in December 2015 and the site is now under decommissioning and closure.

Doral commenced mining the Yoongarillup Mineral Sands Deposit (Yoongarillup Mine), located 17km southeast of Busselton, in January 2017 in accordance with Ministerial Statement No. 1030. Doral also operates a Dry Separation Plant at Picton, 10km east of Bunbury, which receives HMC from Doral's Yoongarillup Mine.

Employing approximately 100 staff and contractors, Doral's business is a source of employment locally and provides business for suppliers, distributors and local services (e.g. mechanics, contractors, consultants). Doral contributes financial support to local schools, sporting groups, various volunteer groups, and annual local festivals and is considered a valuable member of the local community.

Mining operations at Doral's Yoongarillup Mine are anticipated to be completed in 2020. An alternative ore source is therefore required to continue to meet global demand and to ensure the continued employment of Doral's employees and contractors. Commencement of mining operations at the Yalyalup Mineral Sands Project at the commencement of 2021 will enable Doral to continue operating in the southwest of Western Australia and ensure employees and contractors are retained in the southwest and local support to communities continues.

2.2. ALTERNATIVES CONSIDERED

Doral have analysed the alternatives to mining the Yalyalup Mineral Sands Deposit. A discussion of the alternatives is provided as follows.

IS THIS PROPOSAL NEEDED

Doral is a global supplier of the products of mineral sands mining (ilmenite, leucoxene, rutile and zircon). Continuation of mining is core to Doral's business and crucial to continue to deliver to a global market.

Ilmenite, rutile, leucoxene (an alteration product of ilmenite) and HITI (which is a blend of ilmenite and leucoxene) are mainly used to make pure white, highly light refractive and ultra-violet light absorbing, Titanium Dioxide pigment for use in protective house and car paints; paper; plastics; ink; rubber; textiles; cosmetics; sun screens; leather and ceramics. Because titanium dioxide is non-toxic and biologically inert, it can be safely used in foodstuffs and pharmaceuticals. Super strong, lightweight and corrosion resistant titanium metals are also used in the construction of aircraft, spacecraft and motor vehicles, and for medical implants. Again, its non-reactive properties make titanium one of the few materials the human body will not reject; consequently, it is widely used in such medical operations as hip replacements and the installation of heart pacemakers. This super metal is also being increasingly used in the manufacture of strong, lightweight sports equipment, jewellery and other advanced engineering applications.

Zircon is used in ceramics, specialty castings and various refractory applications, where its resistance to high temperature and abrasion make it extremely valuable in the manufacturing processes as well as ceramics such as glazes for tiles and sanitary wear. In industry, it is mainly used as a raw material in making refractory bricks, furnace linings and producing pigments in the ceramic industry; where its opacity and hardness gives a whiteness and durability to tiles, sanitary ware and tableware. It is also utilized in a range of other high-tech industrial and chemical applications.

Doral's operations meet a global need for ilmenite, rutile and zircon and provide West Australian people with employment. Doral currently sources ore to produce these products from its Yoongarillup Mine, which is scheduled for closure in 2020. An alternative ore source is required to continue to meet global demand and to ensure the continued employment of Doral's employees.

OTHER TECHNOLOGIES OR OPTIONS

Open cut mining of mineral sands is standard practise in Western Australia due to the shallow nature of the deposits, which generally occur between 5 to 10m deep in the region. Deposits are usually strand-like and occur at the location of ancient shorelines. Disturbance occurs only on the surface layers and not at depth compared to other forms of mining (e.g. iron ore mining can have pit depths of greater than 60m deep). The use of alternative technologies can be more expensive (e.g. horizontal drilling) and have their own associated impacts and may not result in fewer disturbances to the environment.

LOCATION OPTIONS

Doral are constrained spatially, as the location of mineral sands deposits are the targeted location, and in the southwest region these are largely associated with the foothills of the Whicher Scarp. The grade of HMC discovered through exploration drilling largely determines the areas that are viable and can be extracted for sale. In this case Doral have conducted extensive exploration drilling, and the results of aircore testing indicate the area contains viable mineral. Doral hold other tenements in the southwest however economic resources have yet to be defined for these. As such no environmental or technical studies have been undertaken on these tenements.

OPTIMISATION OF PROPOSAL TO MINIMISE ENVIRONMENTAL IMPACTS

The design of the Proposal and placement of mine pits is continually evaluated through exploration drilling. Exploration drilling commenced in 2012 and since that time Doral have designed a series of mine pit configurations, resulting in the layout presented in this ERD for referral to the EPA. Further exploration drilling is planned for late 2017 and as such further modifications to the Proposal layout are possible.

Due to the early stage of the Proposal, the only design optimisation that has been incorporated into the layout of the mine pits to minimise environmental impacts is:

- Areas containing native vegetation have been avoided where possible (McGibbon Track) to minimise the need to clear vegetation.

Other design optimisations that will be incorporated into the layout of the Proposal will likely include:

- Utilising mine voids where possible for ponds and location of mine infrastructure to reduce the total area disturbed;
- Location of processing equipment in-pit (e.g. hopper) to minimise noise emissions to sensitive receptors;

- Incorporation of noise bunds to minimise potential noise impacts under certain wind conditions on nearby residences;
- Incorporation of several options for emergency discharge of water in the event of heavy rainfall.

2.3. PROPOSAL DESCRIPTION

The Proposal is to allow mining of the Yalyalup Mineral Sands Deposit located approximately 11km southeast of Busselton, Western Australia (Figure 1-1 and Figure 2-1). Ore from the deposit will be mined progressively via a series of open-cut pits using dry mining techniques. Dewatering of groundwater inflows into the pit will be required to enable dry mining to occur. Mining will be staged in order to minimise the area of disturbance (at any one time) with the aim of achieving focussed and effective management of the environmental factors at each pit location, prior to moving onto the next pit location.

Processing of ore will commence in-pit and then slurry will be pumped from the feed preparation plant to the wet concentration plant for further processing. Waste clay and sand materials from processing of this ore will be combined and backfilled into the mine voids using co-flocculation (co-disposal system) where possible. Some material will be initially placed in a Tailing Storage Facility, herein referred to as Solar Evaporation Ponds (SEPs), to allow drying of the clay and recycling of water back to the process water pond (PWP) (return water), prior to being co–disposed into mine voids. The mined area will be rehabilitated back to pasture and/or native vegetation, depending on pre-mining conditions, consistent with the post-mine land use requirements.

HMC produced at the wet concentrator plant will be stockpiled on site prior to transport to Doral's Picton Dry Separation Plant, located ~60km northeast of the mine, for separation using electrostatic processes. The Picton Dry Separation Plant has a licence to process HMC sourced from Doral's Yoongarillup Mine. Processing of HMC into products of zircon, ilmenite, and leucoxene has occurred since the Picton Dry Separation Plant was approved by Ministerial Statement No. 484 in 1998. Once processed, HMC products are hauled by truck to either the Bunbury Port or Fremantle Port for export. Processing activities at the Picton Dry Separation Plant and exporting of product are not part of this Proposal and are not further described in this referral document.

Key characteristics for the Proposal are summarised in Table 2-1 and Table 2-2.

TABLE 2-1: SUMMARY OF THE PROPOSAL

Proposal title	Yalyalup Mineral Sands Mine
Proponent name	Doral Mineral Sands Pty Ltd
Short description	The Proposal is to develop, mine, rehabilitate and decommission the Yalyalup Mineral Sands Mine. The Proposal includes the development of mine pits and associated infrastructure, wet concentration processing plant, solar evaporation ponds, groundwater abstraction and water management infrastructure and process water pond. The life of mine is expected to be 4.5 to 5.5 years.

TABLE 2-2 LOCATION AND PROPOSED EXTENT OF PHYSICAL AND OPERATIONAL ELEMENTS

ELEMENT	LOCATION	PROPOSED EXTENT
Physical Elements		
Mine pits	Figure 2-1	Clearing of ~1.53 ha of native vegetation and ~332.79ha of cleared pasture and exotic planted species within the 894.17ha Development Envelope
Associated infrastructure	Figure 2-1	Clearing of ~0.14ha of native vegetation and ~7.71ha of pasture within a 894.17ha Development Envelope
Solar Evaporation Ponds	Figure 2-1	Clearing of no more than 30.5ha of cleared pasture within a 894.17ha Development Envelope
Operational Elements		
Groundwater Abstraction		Abstraction of up to 2.4 gigalitres (GL) per annum from the Yarragadee aquifer
Ore processing (waste)		250,000 tonnes per annum

2.4. LOCAL AND REGIONAL CONTEXT

The Proposal is located approximately 11km southeast of Busselton, Western Australia and is situated within the Perth Coastal Plain (SWA2) sub-region of the Swan Coastal Plain biogeographic region, as defined in the Interim Biogeographical Regionalisation for Australia (IBRA) (Australian Government, 2013).

The City of Busselton's Local Planning Scheme (LPS) No. 21 (TPS 21) shows the Development Envelope as being zoned as 'Agriculture'. There are 22 Lots within the Development Envelope, however only 12 of these Lots will be directly disturbed for the proposal (i.e. mined or used for infrastructure). Access to landowners properties will be made available via compensation agreements. The lot numbers, landowners and land tenure that will be affected by this Proposal are summarised in Table 2-3.

TABLE 2-3: LAND TENURE AND LANDOWNER STATUS FOR THE PROPOSAL

LOT NUMBER	LANDOWNER	LAND TENURE
608	Private Ownership	Freehold
103	Private Ownership	Freehold
104	Private Ownership	Freehold
729	Private Ownership	Freehold
1609	Private Ownership	Freehold
3752	Private Ownership	Freehold
44	Private Ownership	Freehold
1293	Private Ownership	Freehold

LOT NUMBER	LANDOWNER	LAND TENURE
843	Private Ownership	Freehold
758	Private Ownership	Freehold
1426	Private Ownership	Freehold
3773	Private Ownership	Freehold

The Proposal is located nearby to the following RAMSAR listed wetland and other developments, as shown on Figure 1-1:

- RAMSAR listed Vasse-Wonnerup System Wetland – located ~4.6km north-northwest
- Cristal Wonnerup Mineral Sands Mine - located ~4km north-northwest
- Iluka Resources Ltd Tutunup South Mineral Sands Mine- located ~2.5km southeast
- Doral's Yoongarillup Mineral Sands Mine - located ~6km southwest.

3. STAKEHOLDER ENGAGEMENT

3.1. KEY STAKEHOLDERS

Stakeholder consultation for the Project commenced in 2012 after the purchase of tenements from Iluka Resources Ltd. Several campaigns of exploration drilling were undertaken between 2012-2015 within and surrounding the Development Envelope. Several changes in land ownership have occurred during this time with new owners being progressively consulted about the Proposal. In May 2017 consultation with landowners directly affected by the Proposal commenced in relation to the EPA Referral process. Doral engaged stakeholders early in the planning process to achieve a collaborative approach and to ensure local knowledge is considered in the design, operation and management of the Project. The key stakeholders for the Proposal are considered to include the following:

- Landowners;
- Department of Water and Environmental Regulation (DWER);
- Department of Biodiversity, Conservation and Attractions (DBCA);
- Department of Mines, Industry regulation and Safety (DMIRS);
- Department of the Environment and Energy (DoEE);
- Mains Road WA;
- City of Busselton.

3.2. STAKEHOLDER ENGAGEMENT STRATEGY

Doral will adopt the following stakeholder engagement strategy (Table 3-1) to ensure effective engagement between Doral and stakeholders is occurring during the life of the Project. The objective of the stakeholder engagement strategy is to provide open, transparent information about the Project with stakeholders and to consider all concerns raised by stakeholders, where appropriate.

To ensure that adequate resources are available for ongoing consultation with stakeholders, Doral have tasked an employee to be the Community Liaison Representative with the responsibility of ensuring that consultation with landowners occurs as per the strategy. Doral's OHS&E Superintendent will be responsible for all consultation with regulators.

TABLE 3-1 STAKEHOLDER ENGAGEMENT STRATEGY

STAKEHOLDER	FREQUENCY OF ENGAGEMENT	METHOD OF ENGAGEMENT
INTERNAL		
Mine Manager	Weekly/Monthly/Annually	Weekly production meeting Monthly management meeting Annual consultation during the annual reporting period
Mine Engineer		
Production Superintendent		
OHS&E Superintendent		
General Manager		

STAKEHOLDER	FREQUENCY OF ENGAGEMENT	METHOD OF ENGAGEMENT
Senior Accountant		
Maintenance Manager		
Technical Superintendent		
EXTERNAL		
DWER	6 monthly	Meeting to discuss and document progress of mining activities
DBCA	6 monthly	
DoEE	Annually (or as required)	
DMIRS	Annually (or as required)	
Landowners	6 monthly	House calls to discuss the following with landowners: • Project updates; • Scheduled events; • Concerns by landowners; • Closure items.

3.3. STAKEHOLDER CONSULTATION

Stakeholder consultation has initially comprised meetings, telephone calls and emails with affected landowners discussing preliminary details of the Proposal. To date one to two events has been undertaken as detailed below.

EVENT 1

- Overview of the mining tenure on affected properties
- Results of drilling programs undertaken by Doral to date;
- Pre-feasibility study indicates a Proposal could potentially sustain a 4.5-5.5 year operation;
- Feasibility study scheduled for completion in late 2017;
- Scope and purpose of planned environmental technical studies such as flora/vegetation, fauna and water;
- Access arrangements for affected properties to complete non-intrusive environmental technical studies;
- Approximate commencement timeframe for proposal depending on approval timeframes;
- Simplified mine plan and possible locations for key infrastructure such as concentrator, power, water and haulage access.

EVENT 2

- Process by which Doral develops their mining tenements from acquisition to operations to clarify landowners rights;
- Preliminary mine plans were described, indicating that the Proposal may be a 24 hour continuous operation and had a proposed mine life of between 4.5 to 5.5 years;
- Water, power and access services were further discussed (following on from Event 1);
- Environmental technical studies including flora/vegetation, fauna, water and ethnographic were discussed;
- It was indicated that one of the potential impacts of the Proposal was in relation to groundwater drawdown and the presence of potential acid sulfate soils in the deeper strand ore;
- Submission of an EPA referral under section 38 of the EP Act to determine the level of assessment for the Proposal. This referral will include an environmental impact assessment of the Proposal based on the technical studies;
- Groundwater and surface water monitoring programs would be continued and towards the end of 2017, additional groundwater bores more specific to the proposal would be installed;
- The feasibility study was generally on schedule to be completed by the end of 2017.

Following submission of the EPA referral, meetings with key Government agencies to discuss various aspects of the Proposal, relevant to the identified significant environmental factors, will be undertaken with the following:

- DWER;
- DBCA;
- DMIRS;
- DoEE;
- Mains Road WA;
- City of Busselton.

TABLE 3-2 STAKEHOLDER CONSULTATION

STAKEHOLDER		DATE	DESCRIPTION OF ENGAGEMENT	STAKEHOLDER COMMENTS/ISSUES
Landowners				
Lot 758	Peter & Anna Macleay	23/05/17	See items discussed in Event 1	Receptive to mining and environmental studies. Raised concerns about the close proximity of house to the mine and how Doral would impact on their plans going forward.
		21/09/17	See items discussed in Event 2	Receptive to mining and environmental studies. Were going to have a look at how the Proposal would impact on them. Had concern about existing vegetation.
Lot 843	Peter & Anna Macleay	23/05/17	See items discussed in Event 1	Receptive to mining and environmental studies. Raised concerns about the close proximity of house to the mine and how Doral would impact on their plans going forward.
		21/09/17	See items discussed in Event 2	Receptive to mining and environmental studies. Were going to have a look at how the Proposal would impact on them. Had concern about existing vegetation.

STAKEHOLDER		DATE	DESCRIPTION OF ENGAGEMENT	STAKEHOLDER COMMENTS/ISSUES
Lot 103	Kim & Jackie Hester	23/05/17	See items discussed in Event 1	Receptive to mining and environmental studies. Had concern about deeper mining voids on their property and affect on water.
		26/09/17	See items discussed in Event 2	Receptive to mining and environmental studies. Had concern about current water quality, a colony of bandicoots and lights from the operation.
Lot 104	Kim & Jackie Hester	23/05/17	See items discussed in Event 1	Receptive to mining and environmental studies. Had concern about deeper mining voids on their property and effect on water.
		26/09/17	See items discussed in Event 2	Receptive to mining and environmental studies. Thought the area on their land was too small to warrant. Had concern about current water quality, a colony of bandicoots and lights from the operation.
Lot 1426	Alan & Keren Bashford	25/05/17	See items discussed in Event 1	Receptive to mining and environmental studies.
Lot 200	Gronya Swift	1/06/17	See items discussed in Event 1	Receptive to mining and environmental studies.

STAKEHOLDER		DATE	DESCRIPTION OF ENGAGEMENT	STAKEHOLDER COMMENTS/ISSUES
				Did not want mining on their property. Was concerned about water and having problems with her own water supply.
Lot 292	Justine Mitchell& Nicole Anstey	9/6/17	Email See items discussed in Event 1	Unable to have any meaningful dialogue. Have forwarded brief email description of Proposal (as detailed in Event 1).
Lot 3752	Renea Jones, John Scott & Kaye Scott	11/05/17	See items discussed in Event 1	Receptive to mining and environmental studies. Were concerned about how this would impact on their operations and native vegetation on the McGibbon Track.
Lot 3773	Darryl Boardman & Terry Boardman	27/5/17	See items discussed in Event 1	Receptive to mining and environmental studies. Preferred that Doral buy their property.
		21/9/17	See items discussed in Event 2	Receptive to mining and environmental studies.
Lot 421	Jeremy Stephani	6/06/17	See items discussed in Event 1	Receptive to mining and environmental studies. Indicated that he was looking at building a house on that lot.
		26/9/17	See items discussed in Event 2	Receptive to mining and environmental studies.

STAKEHOLDER		DATE	DESCRIPTION OF ENGAGEMENT	STAKEHOLDER COMMENTS/ISSUES
				Brought along sister Emily who was also looking at moving into an existing house on the property.
Lot 4551	Mark Anthony Conrau	No contact		
Lot 552	Alan & Keren Bashford	25/05/17	See items discussed in Event 1	Receptive to mining & environmental studies.
Lot 608	John Scott	11/05/17	See items discussed in Event 1	Receptive to mining and environmental studies. Were concerned about how this would impact on their operations and native vegetation on the McGibbon Track.
Lot 1293	John Scott	11/05/17	See items discussed in Event 1	Receptive to mining and environmental studies. Were concerned about how this would impact on their operations and native vegetation on the McGibbon Track.
Lot 668	Shaun Parkin & Rebecca Slade	1/6/17	See items discussed in Event 1	Receptive to mining and environmental studies. Enquired as to why Doral had taken so long to be looking at mining.
Lot 971	Pip Phillips	mid May	Telephone call See items discussed in Event 1	Receptive to mining and environmental studies.

STAKEHOLDER		DATE	DESCRIPTION OF ENGAGEMENT	STAKEHOLDER COMMENTS/ISSUES
		27/9/17	See items discussed in Event 2	Receptive to mining and environmental studies.
Lot 404	John Scott	11/05/17	See items discussed in Event 1	Receptive to mining and environmental studies. Were concerned about how this would impact on their operations and native vegetation on the McGibbon Track.
Lot 1322	John Scott	11/05/17	See items discussed in Event 1	Receptive to mining and environmental studies. Were concerned about how this would impact on their operations and native vegetation on the McGibbon Track.
Lot 229	Pip Phillips	mid May	Telephone call See items discussed in Event 1	Receptive to mining and environmental studies.
		27/9/17	See items discussed in Event 2	
Lot 667	Alan & Keren Bashford	25/05/17	See items discussed in Event 1	Receptive to mining and environmental studies.
Lot 1609	Renea Jones, John Scott & Kaye Scott	11/05/17	See items discussed in Event 1	Receptive to mining and environmental studies. Were concerned about how this would impact on their operations and native vegetation on the McGibbon Track.

4. ENVIRONMENTAL PRINCIPLES AND FACTORS

4.1. PRINCIPLES

The EP Act sets out five principles by which protection of the environment is to be achieved in Western Australia. These principles, and the manner in which Doral has sought to apply them in the design and planned implementation of the Proposal, are outlined in Table 4-1.

TABLE 4-1: EP ACT PRINCIPLES

PRINCIPLE	CONSIDERATION
1. Precautionary Principle Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation. In the application of the precautionary principle, decisions should be guided by: • Careful evaluation to avoid, where practicable, serious or irreversible damage to the environment • An assessment of the risk weighted consequences of various options.	The precautionary principle has been applied where lack of full scientific certainty of the impacts of the Proposal are known to prevent environmental degradation.
2. Intergenerational Equity The present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations.	Doral recognises the importance of intergenerational equity and throughout the management measures sections of this ERD, measures to appropriately manage potential impacts to ensure health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations are presented.
3. Conservation of biological diversity and ecological integrity Conservation of biological diversity and ecological integrity should be a fundamental consideration.	Doral recognises the values of native vegetation present within the Development Envelope and have designed the Proposal to avoid clearing vegetation as far as practicable.
4. Improved valuation, pricing and incentives mechanisms i. Environmental factors should be included in the valuation of assets and services. ii. The polluter pays principle – those who generate pollution and waste should bear the cost of containment, avoidance or abatement. iii. The users of goods and services should pay prices based on the full life cycle costs of providing goods and services,	Doral have factored in the costs of implementing environmental management measures into annual budgets for the Proposal. Costs of rehabilitation and decommissioning will be further considered and included in the Mine Closure Plan.

PRINCIPLE	CONSIDERATION
including the use of natural resources and assets and the ultimate disposal of any wastes. iv. Environmental goals, having been established, should be pursued in the most cost-effective way, by establishing incentives structures, including market mechanisms, which enable those best placed to maximise benefits and/or minimise costs to develop their own solutions and responses to environmental problems.	
5. Waste minimisation All reasonable and practicable measures should be taken to minimise the generation of waste and its discharge.	Doral's Environmental Management System (EMS) includes waste management plans, waste management procedures and incident reporting procedures which will be communicated to staff in inductions and regular meetings to ensure best practise management of wastes is implemented at the Yalyalup Mine.

5. FLORA AND VEGETATION

For the purposes of EIA, flora is defined as native vascular plants and vegetation is defined as groupings of different flora patterns across the landscape that occur in response to environmental conditions.

5.1. EPA OBJECTIVE

The EPA objective for Flora and Vegetation is:

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

5.2. POLICY AND GUIDANCE

Guidance relevant to flora and vegetation are documented in the following documents:

- *Environmental Factor Guideline – Flora and Vegetation* (EPA, 2016b)
- *Technical Guidance - Flora and Vegetation Surveys for Environmental Impact Assessment* (EPA, 2016c).

5.3. CONSULTATION

Consultation will be undertaken with:

- DBCA;
- DoEE;
- Other interested parties.

5.4. RECEIVING ENVIRONMENT

SURVEYS COMPLETED

Ecoedge Environmental (Ecoedge, 2016) undertook a Level 1 Flora and Vegetation Survey of remnant vegetation within the proposed mining area (excluding Lots 667, 668, 4551 and 1426 from within the Development Envelopment) in September and October 2015, and February 2016 in accordance with *EPA Guidance Statement 51 – Terrestrial Flora and Vegetation Surveys for environmental Impact Assessment in Western Australia* (EPA, 2004a). All areas of remnant native vegetation within the survey area were visited on foot or by vehicle and data on plant species composition and vegetation was collected at 105 sites. It should be noted that since this survey was undertaken, Doral have more clearly defined the Development Envelope, which is smaller in area than that surveyed by Ecoedge (2016). As such, some flora species and vegetation units identified by Ecoedge (2016) are now located outside of the Development Envelope.

Areas excluded from the initial survey within the Development Envelope (i.e. Lots 667, 668, 4551 and 1426) are due to be surveyed in late October/early November 2017 and will incorporated into future Environmental Review documentation.

Ecoedge (2016) is provided as Appendix 1.

SOIL-LANDSCAPE SYSTEM

The Development Envelope is situated on the Abba Plains soil-landscape system (213Ab). The Abba Plain is a level to gently undulating plain formed on alluvium. It is situated on the southern Swan Coastal Plain and extends for about 10km inland between the Ludlow Plain system to the north and the foot of the Blackwood

Plateau system to the south. It lies approximately 10-40m above sea level and contains extensive areas of poor drainage (Tille & Lantzke, 1990). The total area of the Abba Plain soil-landscape system is 48,954ha.

Soil-landscape systems have been further divided into subsystems, and within these into soil phases or mapping units. Within the Abba Plains, the Development Envelope is situated on soils of the Abba and Jindong Subsystems.

Within the Abba Subsystem, Tille and Lantzke (1990) have identified eleven soil phases or mapping units. Six of these occur within the Development Envelope. Two of the four units mapped for the Jindong Subsystem are also present within the Development Envelope as described in Table 5-1 and shown on Figure 5-1.

TABLE 5-1: SOIL MAPPING UNITS OCCURING WITHIN THE DEVELOPMENT ENVELOPE

SOIL MAPPING UNIT	DESCRIPTION
213AbABw	Winter wet flats and slight depressions with sandy grey brown duplex (Abba) and gradational (Busselton) soils.
213AbABvw	Small narrow swampy depressions along drainage lines. Alluvial soils.
213AbAB1	Flats and low rises with sandy grey brown duplex (Abba) and gradational (Busselton) soils.
213AbABd	Gently sloping low dunes and rises (0-5% gradients) with deep bleached sands.
213AbABwi	Winter wet flats and slight depressions with shallow red brown sands and loams over ironstone (i.e. bog iron ore soils).
213AbABwy	Poorly drained depressions with some areas which become saline In summer. Shallow sands over clay subsoils (i.e. Abba Clays).
213AbJD1	Well drained flats with sandy gradational grey brown (Busselton) soils, some red brown sands and loams (Marybrook Soils).
213AbJDf	Well drained flats with deep red brown sands, loams and light clays (i.e. Marybrook soils).

VEGETATION COMPLEXES

Utilising the recent extension of the vegetation complex mapping within the Swan Coastal Plain (Webb, et al., 2016) remnant vegetation within the Development Envelope (mapped by Ecoedge, 2016) (36.37ha) is mapped as Abba vegetation complex as described in Table 5-2 and shown on Figure 5-2.

TABLE 5-2: VEGETATION COMPLEXES OCCURING WITHING WITHIN THE DEVELOPMENT ENVELOPE

VEGETATION COMPLEX	SYSTEM 6 CODE	DESCRIPTION	CURRENT AREA REMAINING (HA)	PERCENTAGE OF COMPLEX REMAINING (%)	AREA OF VEGETATION MAPPED WITHIN DEVELOPMENT ENVELOPE (HA)
Abba	30	A mixture of open forest of Corymbia calophylla (Marri) - Eucalyptus marginata (Jarrah) - Banksia species and woodland of Corymbia calophylla	3,359	6.6%	36.37

		(Marri) with minor occurrences of Corymbia haematoxylon (Mountain Marri). Woodland of Eucalyptus rudis (Flooded Gum) - Melaleuca species along creeks and on flood plains.			

DESKTOP ASSESSMENT THREATENED AND PRIORITY ECOLOGICAL COMMUNITIES

Ecoedge (2016) undertook a DPaW (now DBCA) database search for threatened or priority ecological communities known to occur within a 5km radius of the Development Envelope (DPaW 2015a and 2015b, cited in Ecoedge 2016). A Threatened Ecological Community (TEC) is one which is found to fit into one of the following categories; Presumed Totally Destroyed (PD), Critically Endangered (CE), Endangered (E) or Vulnerable (V) (DEC, 2010).

Possible threatened ecological communities that do not meet survey criteria are added to DBCA's Priority Ecological Community Lists under Priorities 1, 2 and 3 (referred to as P1, P2, P3). Ecological Communities that are adequately known, are rare but not threatened, or meet criteria for Near Threatened, or that have been recently removed from the threatened list, are placed in Priority 4 (P4). These ecological communities require regular monitoring. Conservation Dependent ecological communities are placed in Priority 5 (P5) (DEC, 2010). The current listing of Threatened and Priority Ecological Communities is specified in DPaW (2015a and 2015b, cited in Ecoedge, 2016).

A Protected Matters Search Tool query was also undertaken for communities listed under the EPBC Act occurring within a 5km radius of the Development Envelope (DoEE, 2015b, cited in Ecoedge, 2016). There are three categories of TEC under the EPBC Act: Critically Endangered (CE), Endangered (E) and Vulnerable (V). Results of these searches are provided in Table 5-3.

TABLE 5-3: THREATENED AND PRIORITY ECOLOGICAL COMMUNITIES DATABASE SEARCH RESULTS

COMMUNITY NAME	DESCRIPTION	CONSERVATION STATUS (WC ACT)	CONSERVATION STATUS (EPBC ACT)
Claypans of the Swan Coastal Plain	Includes the following Western Australian listed Threatened Ecological Communities (TECs): • Herb rich saline shrublands in clay pans (SWAFCT07); • Herb rich shrublands in clay pans (SWAFCT08); • Dense shrublands on clay flats (SWAFCT09); • Shrublands on dry clay flats. (SWAFCT10a). and the following Priority Ecological Community (PEC): • Clay pans with shrubs over herbs.	-	CR
SWAFCT10b - Shrublands on southern Swan	Species rich plant community located on seasonal wetlands on ironstone and heavy clay soils on the Swan Coastal Plain near Busselton.	CR	EN

COMMUNITY NAME	DESCRIPTION	CONSERVATION STATUS (WC ACT)	CONSERVATION STATUS (EPBC ACT)
Coastal Plain Ironstones (Busselton area)	Much of the high species diversity comes from annuals and geophytes.		
SWAFCT01b – Southern *Corymbia calophylla* woodlands on heavy soils	Dominated by *C. calophylla* and *Eucalyptus marginata. Acacia extensa, Hypocalymma angustifolium* and *Xanthorrhoea preissii* are important shrubs. Mainly occurs south of Capel.	VU	-
SWAFCT21b - Southern *Banksia attenuata* woodlands	Structurally, this community type is normally *Banksia attenuata* or *Eucalyptus marginata – B. attenuata* woodland. Common taxa include *Acacia extensa, Jacksonia* sp. *Busselton, Laxmannia sessiliflora, Lysinema ciliatum* and *Johnsonia acaulis.*	P3	-

VEGETATION UNITS

Ecoedge (2016) identified and mapped eight vegetation units within the survey area (Figure 5-3), totaling 36.37ha. Most areas of remnant vegetation are in Degraded or Completely Degraded condition and consequently had low species diversity. As such, it was generally only possible to separate vegetation types based on overstorey composition and to a lesser extent soil type (Ecoedge, 2016). Vegetation units are described in Table 5-4 and includes comments on their conservation status.

TABLE 5-4 VEGETATION UNITS WITHIN SURVEY AREA

VEGETATION UNIT	DESCRIPTION	COMMENTS AND CONSERVATION STATUS	AREA WITHIN DEVELOPMENT ENVELOPE (HA)
A1	Woodland of *Corymbia calophylla* and *Eucalyptus marginata*, with scattered *Agonis flexuosa*, *Banksia attenuata*, *B. grandis*, *Melaleuca preissiana*, *Nuytsia floribunda*, *Persoonia longifolia* or *Xylomelum occidentale* over *Xanthorrhoea preissii* over weeds on grey-brown or grey loamy sand or sand (on farmland usually only *C. calophylla* and *E. marginata* are present).	Degraded form of SWAFCT01b - Southern *Corymbia calophylla* woodlands on heavy soils (Gibson, et al., 2000) which is listed as a Threatened Ecological Community (TEC), with threat status of "Vulnerable" by DBCA. Mostly in Degraded or Completely Degraded Condition. Only area of Unit A1 of sufficient size and in good enough condition to be inferred as an occurrence of TEC SWAFCT01b is on McGibbon Track.	10.39
A2	Woodland of *Corymbia calophylla* (sometimes with *Eucalyptus marginata* or *E. rudis*) with scattered *Melaleuca preissiana* or *Banksia littoralis* over open shrubland that may include *Acacia extensa*, *A. saligna*, *Hakea ceratophylla*, *H. lissocarpha*, *H. prostrata*, *H. varia*, *Kingia australis*, *Melaleuca viminea* and *Xanthorrhoea preissii* over weeds on seasonally wet grey loamy sand.	Similar to both SWAFCT01b and SWAFCT02 - Southern wet shrublands, however the predominance of wetland-adapted species characteristics makes it floristically much closer to SWAFCT02. SWAFCT02 is listed as a TEC, with threat status of "Endangered" by DBCA. The occurrence of Unit A2 at the northern end of McGibbon Track in Good Condition is inferred to be an occurrence of TEC SWAFCT02.	4.03
B1	Tall shrubland of *Acacia saligna*, *Banksia squarrosa* subsp. *argillacea*, *Calothamnus quadrifidus* subsp. *teretifolius*, *Hakea oldfieldii* and *Kunzea micrantha* (with scattered emergent *Eucalyptus rudis*) over scattered native herbs including *Drosera glanduligera* and *Sowerbaea laxiflora*, the sedge *Loxocarya magna*, and weeds on shallow red sandy clay on massive ironstone.	Vegetation Unit B1 is recognised as the TEC SWAFCT10b - Shrublands on southern Swan Coastal Plain Ironstones (Busselton area)" (Gibson, et al., 2000); (Meissner & English, 2005). This TEC has a threat status of "Critically Endangered" by DBCA and Endangered under the EPBC Act. The largest occurrence of B1, that on the McGibbon Track (0.34ha) is recognised as an occurrence of Busselton Ironstones community (Webb, 2004) but unaccountably is	0.50

VEGETATION UNIT	DESCRIPTION	COMMENTS AND CONSERVATION STATUS	AREA WITHIN DEVELOPMENT ENVELOPE (HA)
		yet to be added to the DBCA threatened communities' database (A, Webb, DBCA Bunbury, pers. Comm. 22/02/2016, cited in Ecoedge, 2016). Except on McGibbon Track where it is classed as Good condition the small fragments of this unit are Degraded/Good or Degraded condition.	
B2	Woodland of *Eucalyptus rudis* and (in some areas) *Melaleuca rhaphiophylla* over weeds on massive ironstone.	Severely degraded form of SWAFCT10b - Shrublands on southern Swan Coastal Plain Ironstones (Busselton area) recognisable only by the presence of massive ironstone and lateritic boulders at or near surface. Completely Degraded with only the overstorey remaining.	2.93
C1	Woodland of *Eucalyptus rudis* (and sometimes *Corymbia calophylla*) over scattered *Agonis flexuosa* and *Melaleuca rhaphiophylla* over weeds on grey-brown clayey loams in drainage lines.	Riverine Jindong Plant Communities (Webb, et al., 2009). All in Completely Degraded condition.	17.97
C2	Open woodland of *Melaleuca preissiana* over weeds on seasonally wet brown clay-loam.	SWAFCT04 - *Melaleuca preissiana* damplands. Small area on farmland – Completely Degraded	Not within Development Envelope
C3	Tall Open Shrubland that may include *Acacia saligna*, *Jacksonia furcellata*, *Kingia australis*, *Melaleuca osullivanii*, *M. preissiana*, *M. viminea* and *Xanthorrhoea preissii* on seasonally wet grey-brown sandy loam.	Similarities to the TEC SWAFCT09 - Dense shrublands on clay flats (TEC). However, the occurrence is considered to be too small and badly degraded to be inferred as an example of this TEC. A small area in Degraded/Good or Good condition on the verge of Princefield Road.	0.55

VEGETATION UNIT	DESCRIPTION	COMMENTS AND CONSERVATION STATUS	AREA WITHIN DEVELOPMENT ENVELOPE (HA)
D	Woodland of *Agonis flexuosa* with scattered *Banksia attenuata* over weeds on grey sand on low dunes.	Resemblance to the Priority 3 Ecological Community (PEC) SWAFCT21b - Southern *Banksia attenuata* woodlands" (Gibson, et al., 2000) but has been Completely Degraded by livestock grazing. Situated on farmland – all in Completely Degraded condition.	Not within Development Envelope
PL	Planted Species	Planted non-endemic and exotic trees	4.92
CL	Cleared Pasture	Existing cleared/highly degraded areas (e.g. paddocks/road verges) with scattered trees/shrubs. Some areas seasonally inundated/waterlogged	685.45
Not surveyed	Areas within Development Envelope not surveyed	Majority of non-surveyed areas are cleared farmland with some areas of native vegetation	167.43
TOTAL			894.17

VEGETATION CONDITION

Vegetation condition was assessed against the method detailed in (Keighery, 1994). Most remnant native vegetation within the survey area, and all mapped remnant vegetation on farmland, is in "Completely Degraded" condition. The only vegetation deemed to be in "Good" condition is at the northern end of McGibbon Track and a small area on Princefield Road. A few other small areas were rated by Ecoedge (2016) as "Degraded/Good" condition on McGibbon Track, Princefield Road and Yalyalup Road (Figure 5-4). Vegetation condition is summarised in Table 5-5.

TABLE 5-5: VEGETATION CONDITION

CONDITION SCORE	MAPPED AREA (HA)	PERCENTAGE (%)
Good	2.31	6.3
Degraded/Good	2.43	6.7
Degraded	1.31	3.6
Completely Degraded	30.33	83.4
TOTAL	36.37	100

The main reasons for the generally poor condition of remnant native vegetation in the survey area are the small size of the remnants that are not on farmland, and the fact that all of the remnants on farmland have been grazed for many years.

Small fragments remaining after land clearing are subject to new disturbance regimes, invasive species, disease, increased nutrient loads, and changes in physical edge effects, including changes in wind, temperature, light and humidity (Lindenmayer, 2001). In this altered environment native species, particularly herbaceous taxa, are usually out-competed by agricultural weeds. Long-term grazing of native vegetation by livestock has been shown to cause eventual replacement of the native shrub and herbaceous components by exotic annual grasses and forbs (Pettit, et al., 1998).

WETLANDS AND GROUNDWATER DEPENDENT ECOSYSTEMS

Approximately 808ha (~90%) of the Development Envelope is mapped as a wetland in the Geomorphic Wetlands of the Swan Coastal Plain dataset (DEC, 2008), all of which has been assessed as being in the 'Multiple Use' management category, which is described as wetlands with few ecological attributes and functions remaining. The majority of the wetland area within the Development Envelope (~624ha or 77%) is mapped as Palusplain (seasonally waterlogged flat), with small areas of Sumpland (seasonally inundated basin, ~30ha or 3%) and floodplain (seasonally inundated flats, ~155ha or 17%) (Figure 5-5). No wetlands of environmental significance are present within the Development Envelope.

Detailed information on soil-type and depth to groundwater was not available during the Ecoedge (2016) survey and a such only general comments were made with regard to the presence of likely Groundwater Dependent Ecosystems (GDEs) or phreatophytic vegetation.

Most of the vegetation units identified and mapped by Ecoedge (2016) contain species that are associated with wetland vegetation and potentially phreatophytic. *Eucalyptus rudis, Melaleuca rhaphiophylla, Melaleuca preissiana* and *Banksia littoralis,* one or more of which are present in all but Vegetation Unit D (not within Development Envelope), are known to be groundwater dependent (obligate phreatophytes) on

the Swan Coastal Plain (Water Corporation, 2005). In addition, *Banksia attenuate*, which is typically found on deep sands well above the watertable and within Vegetation Unit D (not within Development Envelope), may also be partially phreatophytic (facultative phreatophytes) (Canham, et al., 2009).

DESKTOP ASSESSMENT THREATENED AND PRIORITY FLORA

Ecoedge (2016) conducted a Naturemap data search for Threatened and Priority flora pursuant to subsection (2) of Section 23F of the WC Act occurring within 10km of the Development Envelope (DPaW, 2014c, cited in Ecoedge, 2016) and a Protected Matters Search Tool query (DoEE, 2014b) for flora listed as Threatened pursuant to Schedule 1 of the EPBC Act occurring within 5km of the Development Envelope (DoEE, 2015b, cited in Ecoedge, 2016). Definitions of Declared Rare and Priority flora under the WC Act and Threatened species under the EPBC Act are provided in Ecoedge (2016). Results of the searches are provided in Table 5-6.

TABLE 5-6: THREATENED AND PRIORITY FLORA POTENTIALLY OCCURING WITHIN DEVELOPMENT ENVELOPE

SPECIES	CONSERVATION STATUS		FLOWERING	DECRIPTION/HABITAT	LIKLIHOOD OF OCCURENCE
	WC ACT	EPBC ACT			
Brachyscias verecundus	T	CE		Annual (or ephemeral), herb, 0.012-0.022 m high, entirely glabrous. Fl. white/cream. In a moss sward. On a granite outcrop.	Low
Caladenia procera	T	CE	Sep-Oct	Tuberous, perennial, herb, 0.35-0.9 m high. Fl. yellow. Rich clay loam. Alluvial loamy flats, jarrah/marri/peppermint woodland, dense heath, sedges.	Low
Andersonia gracilis	T	E	Sep to Nov	Slender erect or open straggly shrub, 0.1-0.5(-1) m high. Fl. white-pink-purple. White/grey sand, sandy clay, gravelly loam. Winter-wet areas, near swamps.	Moderate
Banksia nivea subsp. *uliginosa*	T	E	Aug-Sep	Dense, erect, non-lignotuberous shrub, 0.2–1.5 m high. Fl. yellow, brown. Sandy clay, gravel.	Moderate
Caladenia huegelii	T	E	Sep-Oct	Tuberous, perennial, herb, 0.25-0.6 m high. Fl. green, cream, red. Grey or brown sand, clay loam.	Low
Centrolepis caespitosa	T	E	Oct - Dec	Tufted annual, herb (forming a rounded cushion up to 25 mm across). White sand, clay. Salt flats, wet areas.	Moderate
Darwinia whicherensis	T	E	Oct - Nov	Erect low shrub to 30 cm, flowers green, outer red. Winter-wet area of shrubland over shallow red clay over ironstone	Moderate
Drakaea elastica	T	E	Oct-Nov	Tuberous, perennial, herb, 0.12-0.3 m high. Fl. red, green, yellow. White or grey sand. Low-lying situations adjoining winter-wet swamps	Low
Gastrolobium papilio	T	E	Oct-Dec	Tangled, clumped shrub, to 1.5 m high. Fl. cream-red. Sandy clay over ironstone and laterite. Flat plains.	Low

SPECIES	CONSERVATION STATUS		FLOWERING	DECRIPTION/HABITAT	LIKLIHOOD OF OCCURENCE
	WC ACT	EPBC ACT			
Grevillea maccutcheonii	T	E	Mar/May or Dec	Densely branched shrub, to 2 m high. Fl. green & red. Shallow soils over laterite, clay. Seasonally inundated sites.	Moderate
Lambertia echinata subsp. *occidentalis*	T	E	Feb/May-Jun/Oct	Prickly, much-branched, non-lignotuberous shrub, to 3 m high. Fl. Yellow. White sandy soils over laterite, orange/brown-red clay over ironstone.	Low
Petrophile latericola	T	E	Nov	Multi-stemmed shrub, 0.4-1.5 m high. Fl. yellow. Red lateritic clay. Winter-wet flats.	Moderate
Synaphea stenoloba	T	E	Aug-Oct	Caespitose shrub, 0.3–0.45 m high. Fl. yellow. Sandy or sandy clay soils. Winter-wet flats, granite. Shrublands and woodlands on loamy soils.	Low
Verticordia plumosa var. *vassensis*	T	E	Sep-Feb	Shrub, 0.3–1 m high. Fl. pink, Sep–Feb. White/grey sand. Winter-wet flats	Moderate
Banksia squarrosa subsp. *argillacea*	T	V	Jun-Nov	Erect, open, non-lignotuberous shrub, 1.2–4 m high. Fl. yellow. White/grey sand, gravelly clay or loam. Winter-wet flats, clay flats.	High
Chamelaucium sp. S Coastal Plain (R.D.Royce 4872)	T	V	Aug-Oct	Winter-wet areas, loams and ironstone.	Moderate
Diuris micrantha	T	V	Sep-Oct	Tuberous, perennial, herb, 0.3–0.6 m high. Fl. yellow, brown. Brown loamy clay. Winter-wet swamps, in shallow water.	Moderate
Drakaea micrantha	T	V	Sep-Oct	Tuberous, perennial, herb, 0.15–0.3 m high. Fl. red, yellow. White-grey sand.	Low
Grevillea elongata	T	V	Oct	Shrub, 1.5-2 m high. Fl. white-cream. Gravelly clay, sandy clay, sand. Road verges, swamps, creek banks	Moderate

SPECIES	CONSERVATION STATUS		FLOWERING	DECRIPTION/HABITAT	LIKLIHOOD OF OCCURENCE
	WC ACT	EPBC ACT			
Hemigenia ramosissima	T		Nov–Dec or Jan	Slender shrub, to 0.5 m high. Fl. blue-purple. Lateritic soils, clay. Granite outcrops.	Low
Verticordia plumosa var. *ananeotes*	T		Nov-Dec	Erect, sparsely branched shrub, 0.3-0.5 m high. Fl. pink-purple/white. Sandy loam. Seasonally inundated plains.	Moderate
Gastrolobium sp. Yoongarillup (S.Dilkes s.n. 1/9/1969)	P1		Aug-Oct	Erect, perennial shrub; 0.5 m high, 1.0 m wide; flowers yellow/orange. Jarrah-Marri forest, white sand, gravel	Low
Andersonia ferricola	P1		Oct	Shrub, 0.2-0.5 m high. Fl. purple. White sand or red-brown loam over ironstone. Seasonally wet flats	Moderate
Loxocarya striata subsp. *implexa*	P1		Jul-Dec	Winter-wet flats	Moderate
Stylidium ferricola	P1		…	Caespitose perennial, herb, 0.09-0.15 m high. Shallow red-brown clay loam over ironstone. Seasonally wet poorly-drained slopes.	Moderate
Actinotus whicheranus	P2		Dec or Jan-Mar	Erect, slender perennial, herb, with flowering branches to 0.4 m high. Fl. white. White sand pockets over laterite.	Moderate
Amperea micrantha	P2		Oct-Nov	Low, spreading, bushy perennial, herb, 0.1–0.3 m high. Fl. brown. Sandy soils	Low
Calytrix sp. Tutunup (G.J. Keighery & N. Gibson 2953)	P2		Oct	Slender, spreading shrub, to 3 m high. Fl. white. Yellow-grey clayey loam, red clayey loam, laterite, ironstone. Slopes and flats, winter-wet areas, grazed paddocks.	Moderate
Gratiola pedunculata	P2		Sep-Nov	Erect to decumbent perennial herb 13–50 cm high. Damp areas.	Low

SPECIES	CONSERVATION STATUS		FLOWERING	DECRIPTION/HABITAT	LIKLIHOOD OF OCCURENCE
	WC ACT	EPBC ACT			
Leucopogon sp. Busselton (D. Cooper 243)	P2		Aug-Sep	Slender, erect shrub to 70 cm; flowers white. *Pericalymma ellipticum* wet shrubland, Marri-Jarrah woodland.	Low
Blennospora doliiformis	P3		Oct-Nov	Erect annual, herb, to 0.15 m high. Fl. yellow. Grey or red clay soils over ironstone. Seasonally-wet flats.	Moderate
Boronia capitata subsp. *gracilis*	P3		Jun-Nov	Slender shrub, 0.3-0.6(-3) m high, branches pilose. Fl. pink. White/grey or black sand. Winter-wet swamps,	Moderate
Boronia tetragona	P3		Oct-Dec	Perennial, herb, 0.3–0.7 m high, leaves sessile, entire, with papillate margins, branches quadrangular, sepals ciliate. Fl. pink, red. Black/white sand, laterite, brown sandy loam. Winter-wet flats, swamps, open woodland.	Moderate
Chordifex gracilior	P3		Sep-Dec	Rhizomatous, erect perennial, herb, 0.3-0.5 m high. Fl. brown, Sep to Dec. Peaty sand. Swamps.	Moderate
Conospermum paniculatum	P3		Jul-Nov	Spreading, open shrub, 0.3-1.25 m high. Fl. blue, white. Sandy or clayey soils. Swampy areas, plains, slopes.	Low
Grevillea brachystylis subsp. *brachystylis*	P3		Aug-Nov	Much-branched, prostrate or decumbent, non-lignotuberous shrub, 0.2-0.5 m high, to 3 m wide. Fl. red. Black sand, sandy clay. Swampy situations.	Moderate
Grevillea bronwenae	P3		Jun-Dec	Slender, erect shrub, 0.5–1.6 m high. Fl. red. Grey sand over laterite, lateritic loam. Hillslopes.	Moderate
Hakea oldfieldii	P3		Aug-Oct	Open, straggling shrub, up to 2.5 m high. Fl. white, cream, yellow. Red clay or sand over laterite. Seasonally wet flats.	High

SPECIES	CONSERVATION STATUS		FLOWERING	DECRIPTION/HABITAT	LIKLIHOOD OF OCCURENCE
	WC ACT	EPBC ACT			
Isopogon formosus subsp. *dasylepis*	P3		Jun-Dec	Low, bushy or slender, upright, non-lignotuberous shrub, 0.2–2 m high. Fl. pink, purple, red. Sand, sandy clay, gravelly sandy soils over laterite. Often swampy areas.	High
Lasiopetalum laxiflorum	P3		Sep-Oct	Jarrah forest, lateritic soils	Low
Loxocarya magna	P3		Sep or Nov	Rhizomatous, perennial, herb (sedge-like), 0.5-1.5 m high. Sand, loam, clay, ironstone. Seasonally inundated or damp habitats.	High
Pithocarpa corymbulosa	P3		Jan-Apr	Erect to scrambling perennial, herb, 0.5-1 m high. Fl. white. Gravelly or sandy loam. Amongst granite outcrops.	Low
Schoenus pennisetis	P3		Aug-Sep	Tufted annual, grass-like or herb (sedge), 0.05-0.15 m high. Fl. purple-black. Grey or peaty sand, sandy clay. Swamps, winter-wet depressions.	Moderate
Stylidium longitubum	P3		Oct-Dec	Erect annual (ephemeral), herb, 0.05-0.12 m high. Fl. Pink. Sandy clay, clay. Seasonal wetlands.	Moderate
Verticordia attenuata	P3		Dec-May	Shrub, 0.4–1 m high. Fl. pink. White or grey sand. Winter-wet depressions	Moderate
Acacia flagelliformis	P4		May-Sep	Rush-like, erect or sprawling shrub, 0.3-0.75(-1.6) m high. Fl. yellow. Sandy soils. Winter-wet areas.	Moderate
Acacia semitrullata	P4		May-Oct	Slender, erect, pungent shrub, (0.1-)0.2-0.7(-1.5) m high. Fl. cream, white. White/grey sand, sometimes over laterite, clay. Sandplains, swampy areas.	Moderate
Banksia meisneri subsp. *ascendens*	P4		Apr-Sep	Shrub, 0.5-2 m high, leaves ascending, 8-15 mm long. Fl. yellow-orange-brown. White or grey sand. Swampy flats.	Moderate

SPECIES	CONSERVATION STATUS		FLOWERING	DECRIPTION/HABITAT	LIKLIHOOD OF OCCURENCE
	WC ACT	EPBC ACT			
Calothamnus quadrifidus subsp. *teretifolius*	P4		Nov-Dec	Erect, compact, perennial shrub 1.7 m high x 1 m wide. Fl. Red. Seeds held. Fruit exposed.	High
Chamelaucium sp. Yoongarillup (G.J. Keighery 3635)	P4		Jul-Oct	Non-lignotuberous shrub, to 2.5 m high. Fl. cream, yellow. Jarrah-marri forest. Loams, sandy clays. Riverbanks, lower slopes, below laterite breakaways.	Low
Franklandia triaristata	P4		Aug-Oct	Erect, lignotuberous shrub, 0.2-1 m high. Fl. white, cream, yellow, brown, purple. White or grey sand.	Low
Ornduffia submersa	P4		Sep-Oct	Tuberous emergent aquatic perennial dwarf shrub, height to 35 cm; flowers white; leaves floating on surface of water. Clay-based ponds and swamps (semi-aquatic)	Moderate
Pultenaea skinneri	P4		Jul-Sep	Slender shrub, 1-2 m high. Fl. yellow, orange, red. Sandy or clayey soils. Winter-wet depressions.	Low

FLORA

One hundred and forty-nine taxa of vascular plants were identified during the Ecoedge (2016) survey, of which 57 taxa (38%) were introduced species. The relatively low number of native species found within the ~78 ha of native vegetation in the wider survey area is a result of many years of degradation of the small fragments of native bush. The largest single area of native vegetation is only 6.5ha in size and has been subject to many years of livestock grazing. As a consequence, all native species have been removed from the understorey.

The dominant genera were the Fabaceae with 23 taxa (including 10 introduced species), Proteaceae with 16 taxa, Myrtaceae with 16 taxa (2 introduced species) and Poaceae with 15 taxa (14 introduced species).

FLORA OF CONSERVATION SIGNIFICANCE

Two Declared Rare Flora (DRF) species, *Banksia squarrosa* subsp. *Argillacea* and *Verticordia plumosa* var. *vassensis,* were recorded within the survey area. Both of these species are listed as Threatened pursuant to subsection (2) of Section 23F of the WC Act and Endangered pursuant to section 179 of the EPBC Act.

The population of *B. squarrosa* subsp. *argillacea* within the Development Envelope occurs on McGibbon Track within a small occurrence of Vegetation Unit B1 which is recognised as the TEC SWAFCT10b - Shrublands on southern Swan Coastal Plain Ironstones (Busselton area)" (Gibson, et al., 2000) (Meissner & English, 2005). A total of nine individuals were identified during the survey which is a decline in population since 2003 by five individuals.

The population of *V. plumosa* var. *vassensis* is located outside of the Development Envelope and is situated on the verge of Princefield Road, 2.1km west of Ludlow-Hithergreen Road. The population size was estimated at 200+ plants in 1996, and 100+ in 2006 (Williams, et al., 2001) (DoEE, 2016f, cited in Ecoedge, 2016). The population size was difficult to estimate during the Ecoedge (2016) survey as the plants are situated within an area of thick wet shrubland, however approximately 30 individuals were recorded.

Two Priority listed species pursuant to subsection (2) of section 23F of the WC Act; *Loxocarya magna* (P3) and *Calothamnus quadrifidus* subsp. *teretifolius* (P4) were also recorded within the survey area.

Locations of conservation significant flora are shown on Figure 5-6.

Several other DRF and Priority species previously known to occur in the area were not able to be located during the survey. These include:

- *Chamelaucium* sp. S coastal plain (R.D.Royce 4872) (DRF) (40+ plants in 1997) previously occurred within a small area of ironstone vegetation near the junction of Princefield Road and Coopers Road but this population is now possibly extinct due to burning and grazing of the small remnant (which is situated on a road and drainage reserve);
- *Banksia nivea* subsp. *uliginosa* (DRF) (6 plants in 2003) previously occurred on the verge of Princefield Road 875m west of Coopers Road (Williams, et al., 2001), but this also no longer extant. The road verge shows signs of having been mowed and/or grazed by livestock being herded along this area by farmers;
- One plant of *Verticordia plumosa* var. *vassensis* (DRF) on the verge of Princefield Road 4.3km west of Ludlow-Hithergreen Road in 1996. This plant was not able to be found during the present survey;
- *Isopogon formosus* subsp. *dasylepis* (P3) had previously been known from 200m north along McGibbon Track from Yalyalup Road. This plant was not able to be found during the present survey.

DECLARED PLANTS

Two weeds were found within the Development Envelope, *Asparagus asparagoides* and *Zantedeschia aethiopica*. Both are listed as Pest Plants by the Department of Agriculture and Food (DAF, 2014) and are in the C3 (management) category for the whole of the State. *A. asparagoides* (Bridal Creeper) was only found in four locations, but *Z. aethiopica* (Arum Lily) is widespread within the Development Envelope, particularly along creeklines (Figure 5-7).

5.5. POTENTIAL IMPACTS

The following aspects of the Proposal may affect flora and vegetation values:

- Clearing of ~1.67ha of native vegetation will reduce the extent of soil-landscape systems, vegetation complexes, vegetation units and inferred occurrences of DBCA listed TECs;
- Dewatering activities may indirectly affect potential groundwater-dependent vegetation by lowering local groundwater levels;
- Mining activities and vehicle movement have the potential to spread weeds within and adjacent to the Development Envelope;
- Mining activities and vehicle movement has the potential to deposit dust on vegetation within and adjacent to the Development envelope;

5.6. ASSESSMENT OF IMPACTS

CLEARING OF NATIVE VEGETATION

The Proposal has been designed to avoid clearing native vegetation as far as practicable to reduce impacts to flora and vegetation values. The Proposal however will require clearing of ~1.67ha of native vegetation to facilitate the development of mine areas and associated infrastructure. This will reduce the regional and local extent of soil-landscape systems, vegetation complexes, vegetation units and inferred occurrences of DBCA listed TECs. No DRF or Priority flora species will be cleared for the Proposal.

Soil Landscape Mapping

The Proposal will clear ~1.67ha of native vegetation that occurs within the Abba Plains soil-landscape system (213Ab). Table 5-7 shows the potential impact to the Abba Planis soil-landscape system and soil mapping units (subsystems of the Abba Plains soil-landscape system) that occur within the Development envelope.

TABLE 5-7: POTENTIAL IMPACTS TO SOIL-LANDSCAPE SYSTEMS AND MAPPING UNITS

SOIL MAPPING UNIT	TOTAL EXTENT OF SOIL MAPPING UNIT (HA)	AREA OF SOIL MAPPING UNIT AFFECTED BY PROPOSAL (HA)	PERCENTAGE OF SOIL MAPPING UNIT AFFECTED BY PROPOSAL (%)
TOTAL ABBA PLAINS SOIL-LANDSCAPE SYSTEM	**48,954**	**372.67**	**0.76**
213AbABw	3320	143.66	4.33
213AbABvw	1026	0	0

213AbAB1	2127	190.10	8.94
213AbABd	1495	0	0
213AbABwi	154	35.59	23.11
213AbABwy	871	2.32	0.27
213AbJD1	162	1.01	0.62
213AbJDf	1817	0	0

VEGETATION COMPLEXES

Utilising the recent extension of the vegetation complex mapping within the Swan Coastal Plain (Webb, et al., 2016), clearing of native vegetation for the Proposal will occur in the Abba vegetation complex. As shown in Table 5-8, the area of native vegetation to be cleared represents only 0.05% of the remaining area of the Abba vegetation complex and therefore does not significantly reduce the extent of this vegetation complex.

In 2001, the Commonwealth of Australia stated National Targets and Objectives for Biodiversity Conservation, which recognised that the retention of 30% or more, of the pre-European vegetation of each ecological community was necessary if Australia's biological diversity were to be protected (Environment Australia, 2001). This level of recognition is in keeping with the targets set in the EPA's Position Statement No. 2 (EPA, 2000), with particular reference to the agricultural area. With regard to conservation status, the EPA has set a target of 15% of pre-European extent for each community to be protected in a comprehensive, adequate and representative reserve system (EPA, 2006)

Currently 6.6% of the Abba vegetation complex is remaining which is below the Commonwealth's 30% target and the EPA's 15% target. In addition, only 1.7% of the Abba vegetation complex is in formal reserves.

TABLE 5-8: POTENTIAL IMPACTS TO VEGETATION COMPLEXES

VEGETATION COMPLEX	SYSTEM 6 CODE	PRE EUROPEAN EXTENT OF VEGETATION COMPLEX	CURRENT AREA OF VEGETATION COMPLEX REMAINING (HA)	PERCENTAGE OF VEGETATION COMPLEX REMAINING (%)	AREA OF VEGETATION COMPLEX TO BE CLEARED (HA)	PERCENTAGE OF VEGETATION COMPLEX AFFECTED BY PROPOSAL %
Abba	30	50,892.78	3,359.08	6.6%	1.67	0.05

VEGETATION UNITS

Clearing for the Proposal will require disturbance of ~1.67ha of native vegetation (Table 5-9). The majority of native vegetation to be cleared is within vegetation unit A1, which is inferred to be a degraded form of SWAFCT01b - Southern *Corymbia calophylla* woodlands on heavy soils (Gibson, et al., 2000) and is listed as a TEC, with threat status of "Vulnerable" by DBCA. Vegetation Unit A1 is in mostly Degraded or Completely Degraded Condition, with only a small area of sufficient size and in good enough condition to be inferred as an occurrence of TEC SWAFCT01b is on the McGibbon Track. Clearing of Unit A1

Approximately 0.34ha of vegetation unit A2 will be cleared for the Proposal. This vegetation unit only occurs on the McGibbon Track and has characteristics of both SWAFCT01b (because of the overstorey of *C.*

calophylla) and SWAFCT02 - Southern wet shrublands, however the predominance of wetland-adapted species characteristics such as *Acacia saligna, Banksia littoralis, Melaleuca rhaphiophylla* and *Hakea ceratophylla* makes it floristically much closer to SWAFCT02 which is listed as a TEC, with threat status of "Endangered" by DBCA. The occurrence of vegetation unit A2 at the northern end of McGibbon Track in Good Condition is inferred to be an occurrence of TEC SWAFCT02. Clearing of Unit A1 will primarily occur adjacent (to the east) to McGibbon Track.

Approximately 0.11ha of vegetation unit B2 will be cleared for the Proposal. This unit is a severely degraded form of SWAFCT10b - Shrublands on southern Swan Coastal Plain Ironstones (Busselton area) (vegetation unit B1), recognisable only by the presence of massive ironstone and lateritic boulders at or near surface. Generally, the only native species still present are the trees *Eucalyptus rudis* which is also present within unit B1 on the McGibbon Track, and sometimes *Melaleuca rhaphiophylla*.

The final vegetation unit which will be cleared for the Proposal is vegetation unit C1, of which 0.03% will be cleared. vegetation unit C1 appears to belong to the "Riverine Jindong Plant Communities" as discussed in (Webb, et al., 2009) and is associated with winter streams that flow northwards in the western portion of the Development Envelope towards the Sabina River. All of vegetation unit C1 is in Completely Degraded condition.

The remainder of the disturbance area will occur in cleared pasture (369.35ha), cleared pasture not yet surveyed (47.76ha) and planted exotic species (1.65ha).

TABLE 5-9: POTENTIAL IMPACTS TO VEGETATION UNITS

VEGETATION UNIT	AREA WITHIN DEVELOPMENT ENVELOPE (HA)	AREA TO BE CLEARED (HA)	CLEARING AS A PERCENTAGE OF TOTAL VEGETATION UNIT (%)
A1	10.39	1.19	11.45
A2	4.03	0.34	24.81
B1	0.50	0.0	0.0
B2	2.93	0.11	3.75
C1	17.97	0.03	0.17
C2	Not within Development Envelope		
C3	0.55	0.0	0.0
D	Not within Development Envelope		
PL	4.92	1.65	33.54
CL (includes disturbance area not surveyed)	685.45	369.35	53.88
Not Surveyed	167.43	Included in CL	na

IMPACTS FROM DEWATERING ACTIVITIES

Although no detailed GDE studies have been undertaken for the Site, Ecoedge (2016) noted that the majority of vegetation present within the survey area contains species in their overstory that have been shown to be at least partially phreatophytic.

Due to the scope and timing of the Flora and Vegetation Survey, a detailed review of soil information from existing exploration drilling/assay data, depths to groundwater and proposed dewatering extents, and specific groundwater dependence of on-Site vegetation was not able to be undertaken. In the absence of this detailed review, an initial assumption is that mapped vegetation present above a water table of <3mBGL may be potential GDEs (the depth of 3m is considered to be the normal limit for the evapotranspiration extinction depth in groundwater modelling). As shown in Figure 6-4, with the exception of a small area in the central south, the entire Site is located above a water table shallower than 3 mBGL.

Initial drawdown modelling (although preliminary) (refer to Section 6), indicates that a drawdown of up to 1m may be expected to occur within approximately 560 to 670m of mine pits, which would result in a reduction to groundwater levels and therefore access to groundwater for potential GDEs within the Development Envelope. Further detailed modelling of dewatering drawdowns and identification of GDE's is required to determine the actual impact on GDEs.

SPREAD OF WEEDS

Mining activities and vehicle movements have the potential to result in the spread of weeds within and adjacent to the Development Envelope. Strict weed hygiene measures will be implemented to reduce the risk of weed introduction and spread into areas of native vegetation, which are largely weed free. Measures will be implemented to target the control of the Declared Plants *Asparagus asparagoides* and *Zantedeschia aethiopica*. Weed management will be implemented as per Doral's Flora and Vegetation Management Plan.

IMPACTS FROM DUST DEPOSITION

Mining activities and vehicle movement has the potential to generate dust which may directly affect vegetation within and adjacent to the Development Envelope through deposition of dust on the plants. Dust deposition on the surface of vegetation can adversely impact upon the plant's function and ability to transpire. With controls in place, dust generation can be minimised to the extent that adverse impacts are managed at an acceptable level.

5.7. MITIGATION

Doral's overall principles for mitigating potential impacts to flora and vegetation are to:

- Design the Site to avoid and/or minimise native vegetation clearing and land disturbance, as far as practicable;
- Minimise the timeframe between disturbance and rehabilitation;
- Implement a Flora and Vegetation Management Plan.

Doral will develop and implement a Flora and Vegetation Management Plan to address potential impacts to flora and vegetation. The Flora and Vegetation Management Plan will include the following key management actions:

- Development and implementation of specific clearing procedures to minimise impacts to flora and vegetation. This will include demarcation of cleared areas and authorisation requirements;

- Establishment of specific stockpile management procedures to store and manage crushed vegetation, topsoil and subsoil;
- Any DRF and priority flora species located within the Development Envelope will be avoided and fenced to exclude access;
- Monitor vegetation health, soil moisture and groundwater levels for potential GDEs within the Development Envelope;
- Declared Plants *Asparagus asparagoides and Zantedeschia aethiopica ragoides* will be managed in accordance with the Biosecurity and Agricultural Management Act 2007;
- Weed and dust management measures will be incorporated into the ongoing management of flora and vegetation for the Proposal.

5.8. PREDICTED OUTCOME

After the application of mitigation measures described above, the Proposal will result in the following outcomes in relation to flora and vegetation:

- The Proposal will clear ~1.67ha of native vegetation of which 1.33ha is in Completely Degraded condition, with the remaining 0.34ha in Degraded/Good and Good condition.
- Clearing for the Proposal represents disturbance to 0.76% of the area remaining of the Abba Plains soil-landscape system (48,954ha) and does not significantly reduce the regional extent of this soil-landscape system.
- Clearing for the Proposal represents disturbance to 0.05% of the area remaining for the Abba vegetation complex and does not significantly reduce the extent of this vegetation complex (i.e. 1.67ha of the remaining 3,359.08ha). Currently 6.6% of the Abba vegetation complex is remaining which is below the Commonwealth's 30% target and the EPA's 15% target.
- Two of the vegetation units to be cleared for the Proposal (Unit A1 and A2) are inferred to be Degraded occurrences of the DBCA listed TEC's SWAFCT01b (Southern *Corymbia calophylla* woodlands on heavy soils) and SWAFCT02 (Southern wetland vegetation).
- Populations of DRF and Priority listed flora species will not be cleared for the Proposal.
- Initial drawdown modelling (although preliminary at this stage), indicates that a drawdown of up to 1m may be expected to occur within approximately 560 to 670m of mine pits, which would result in a reduction to groundwater levels and therefore access to groundwater for potential GDEs within the Development Envelope.

Doral recognises that floristically the most important part of the Development Envelope is the 5.1ha of native vegetation located along the McGibbon Track, which has 50% of the total number of native species identified during the Level 1 Flora and Vegetation Survey. As such, the Proposal has been designed to avoid direct disturbance to vegetation along the McGibbon Track, as well as all other areas of native vegetation within the Development Envelope, as far as practicable. In total, ~1.67ha of native vegetation within the Development Envelope will be cleared for the Proposal.

Regionally, clearing will not significantly reduce the remaining area of the Abba Plains soil-landscape system (0.76%) or the Abba vegetation complex (0.05%). Locally (i.e. within the Development Envelope) clearing will reduce the extent of two inferred occurrences of DBCA listed TEC's (Unit A1 - SWAFCT01b and Unit A2 -

SWAFCT02) by 11% and 25%, respectively. However, these TEC's are in mostly Degraded or Completely Degraded condition, with only small areas on the McGibbon Track considered to be of sufficient size and in good enough quality to be considered TEC's. Clearing will not impact any DRF or Priority listed species within the Development Envelope.

Indirect impacts to potentially groundwater dependent vegetation may occur as a result of groundwater drawdown to facilitate mining. Further assessment of groundwater dependent vegetation, soil profiles, hydrology and the impacts of drawdown are required to further assessment indirect impacts to GDE's.

Doral considers that with the implementation of the proposed mitigation measures described above, the EPA's objective to protect flora and vegetation so that biological diversity and ecological integrity are maintained, can be achieved.

6. HYDROLOGICAL PROCESSES

For the purposes of EIA, the EPA defines the factor Hydrological Processes as:

> *The occurrence, distribution, connectivity, movement and quantity of water.*

6.1. EPA OBJECTIVE

The EPA objective for Hydrological Processes is:

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

6.2. POLICY AND GUIDANCE

- *Environmental Factor Guideline – Hydrological processes* (EPA, 2016d)*;*

6.3. CONSULTATION

Consultation will be undertaken with:

- DWER;
- DoEE;
- Other interested parties.

6.4. RECEIVING ENVIRONMENT

INVESTIGATIONS UNDERTAKEN

HydroSolutions (2017) undertook an initial hydrogeological desktop assessment for the Proposal. The objectives of the desktop assessment (Appendix 2) were to:

- Determine background information with regard to the surface water and groundwater systems at the Site and in its vicinity;
- Perform a preliminary assessment of the impact of mine dewatering on the surface water and groundwater systems;
- Identify any other potential impacts on the groundwater environment, including GDEs, Acid Sulfate Soils (ASS), and conservation wetlands and waters.

CLIMATE AND RAINFALL

Meteorological data has been sourced from the Bureau of Meteorology Station 9603 (Busselton Aero). The Busselton Area experiences a Mediterranean climate with warm to hot dry summers, and mild wet winters. High pressure cells dominate climatic patterns during summer and the passage of cold fronts and associated low pressure cells dominate during winter. Strong sea breezes occur from late November to early March. The annual rainfall generally falls within the 800mm and 1000mm range, peaking in June and July. In summer, the average maximum temperature is 29°C with an average minimum temperature of 12°C. In winter, the average maximum temperature is 17°C with an average minimum temperature of 5°C.

Annual mean rainfall for the previous 10 years (2007-2017) is 677mm, which is substantially lower than the long-term average for Busselton of 811mm. The majority of precipitation occurs between the months of May and September, with minimal rainfall (<25mm) in the summer months. Potential average annual evapotranspiration in the region is approximately 1200mm, which therefore is likely to exceed precipitation during summer months.

GROUNDWATER MANAGEMENT AREA

The Development Envelope is wholly within the Busselton-Capel Groundwater Area (BCGA) (Figure 6-1). The Busselton-Capel sub-area covers 757.3km^2 and is predominantly used by the service sector, mining and industry, and horticulture. Currently the Superficial and Leederville aquifers in the subarea are fully allocated (DoW, 2009).

The Development Envelope is also within the Busselton-Yarragadee Groundwater Area (Yarragadee aquifer). The Busselton-Yarragadee subarea covers 2,021.4km^2 (Figure 6-1) and is fully allocated. The predominant use of this aquifer is for public water supply, mining and industry (DoW, 2009).

HYDROGEOLOGY

Groundwater is present in the area within a multi-layered aquifer system. The superficial deposits contain an unconfined aquifer with saturated thicknesses of generally less than 15m, whereas the Leederville and Yarragadee Formations contain multiple regional-scale confined and semi-confined aquifers.

Superficial Aquifer

Unconfined groundwater in the Superficial formations occurs at approximately 1-3mBGL, with a consequent saturated thickness of approximately 10-14m, based on water levels obtained from local bores during initial groundwater monitoring in May-June 2017. Seasonal variation in the water table, derived from existing DWER hydrographs in the area, is in the range of approximately 1-2m. A water table based on initial measurements (May-June 2017) is shown on Figure 6-2, although this is a preliminary estimate only.

Regional groundwater flow is expected to occur to the northwest in the vicinity of the Site, as shown in Figure 6-2, which also indicates a hydraulic gradient within the superficial aquifer of approximately 0.0037 (HydroSolutions, 2017). The ultimate discharge point is likely to be Geographe Bay and the Vasse – Wonnerup RAMSAR wetland, approximately 7.5km to the north-northwest. Recharge occurs by rainfall, although a large proportion of this infiltration is likely to be lost due to evapotranspiration due to the shallow water table.

The Superficial formations are variable across the region and hydraulic conductivities are site-specific. However, in general, hydraulic conductivities have been estimated to be in the range of 0.5-50m/d (Davidson, 1995) (Hirschberg, 1989), with an average of 15m/d, partially dependent on the percentage sand content. The Superficial Aquifer is underlain by a clay-dominated aquitard unit, which also forms a confining layer for the underlying Leederville aquifer; the two aquifers are not expected to be in hydraulic continuity with each other in the Site vicinity (HydroSolutions, 2017).

Leederville Aquifer

The Leederville aquifer is a multi-layered confined aquifer system comprising discontinuous interbedded sequences of sandstone and clay. The various sub-aquifers within the Leederville formation are generally in hydrogeological continuity with each other. Its average thickness regionally is between 150 and 200m over

most of the Hirschberg (1987) study area. The horizontal hydraulic conductivity of sandstone beds in the Leederville aquifer, derived from pumping tests (Davidson, 1995), is about 10m/d, and that of the siltstone and shale beds is assumed to be about 1 x 10^{-6} m/d. If the interbedded sandstones, siltstones and shales are laterally extensive, the average horizontal hydraulic conductivity of the aquifer will approach 5m/d (as the sandstones constitute approximately half the aquifer thickness). Sandy beds that comprise the Vasse Member constitute the main aquifer. The sandy beds underlie the Mowen Member which comprises an aquitard. Hirschberg (1989) reports that upward leakage occurs into the superficial aquifer from the confined aquifers in the vicinity of the Site, although later studies suggest that downward flows have also been occurring since that time, potentially due to ongoing regional abstraction from the Leederville Aquifer (Schafer, et al., 2008). The Leederville Aquifer extensively outcrops throughout the Blackwood Plateau (Schafer, et al., 2008). The seasonal fluctuation of the potentiometric heads in the Leederville aquifer is generally in the range of 1 to 2m (Hirschberg, 1989). Discharge occurs offshore and, over an area of upward hydraulic gradient that extends several km inland, by upward leakage into the Superficial Aquifers (Hirschberg, 1989). Hirschberg (1987) notes that salinity in the upper 100m of the Leederville aquifer is generally less than 500mg/L TDS and is again dominated by sodium and chloride ions. Silica is also noted as being generally greater than normal background concentrations, with a maximum of 50mg/L recorded by Hirschberg (1987) during his study. Water from the Leederville Aquifer is used extensively for private and municipal water supplies.

Based on measured groundwater levels for the Superficial and Leederville aquifers shown on Figure 6-2 and Figure 6-3, there is generally a 2m or greater difference in equipotentials between the groundwater systems at the Site, with lower elevations recorded within the Leederville Aquifer (HydroSolutions, 2017). There are also some instances of upward hydraulic heads and artesian flows in the vicinity of the Site, including reportedly in one bore to the south of the Site (bore Lot 667_WM1).

Water levels obtained from initial groundwater monitoring of local bores indicate a large variation in heads across the Site, with a range from 0.8 to 11.27mBGL, reflecting differences between static water levels (SWL) and pumping water levels (PWL) in bores with active abstractions. Minor uncertainty is attached to the location, condition and elevation reference level of these bores, although these bores will be re-surveyed to millimeter accuracy in late 2017.

Yarragadee Aquifer

The Yarragadee aquifer is composed primarily of non-marine fluvial feldspathic, poorly sorted sandstones which are porous and poorly cemented and, hence, allow for considerable groundwater reserves. It grades from a shale-siltstone dominated base to a cleaner sandstone in the upper portions of the Formation, probably representing increased subsidence or filling of the basin during the late Jurassic (Varma, 2009). Individual sandstone sections are typically 20m or more thick, and are separated by shale beds generally up to 10m thick (Hirschberg, 1989). The Yarragadee Formation is divided into four units. Unit 3, which underlays the Vasse Member in the proposed mining area is reported to be the most transmissive unit (Baddock, et al., 2005). However, isotopic dating of groundwater indicates an average hydraulic conductivity of 8m/d. Salinity in the Yarragadee aquifer is in the range of 230 to 900mg/L TDS and percentages of the major ions are similar to those in the Leederville aquifer, suggesting a close relationship between the two aquifers. Water from the Yarragadee aquifer is primarily for use in town drinking water and for heavy mineral sand processing in the area.

GROUNDWATER USERS

HydroSolutions (2017) identified a total of 65 licenced groundwater abstractors within a 5km radius of the Site using available DWER data (see Appendix 1 of HydroSolutions, 2017). The majority of groundwater usage is stated to be for livestock and domestic/household use, although there are two major abstraction licenses by volume. These are Iluka's Tutunup South Site to the southeast of the Site (6.5 GL/yr), and the Cable Sands (WA) Pty Ltd Site to the north (3.9 GL/yr).

Of the 65 licensed bores, three abstract from the Superficial Aquifer, eight from the Yarragadee Aquifer and 54 from the Leederville Aquifer. The three licences for the Superficial Aquifer are for irrigation of City of Busselton reserves along Vasse Highway, 5km west of the Site, for a private farm user 5km east and up hydraulic gradient of the Site and for Iluka's Tutunup South Site, located 2.5km southeast and upgradient of the Site. All identified licences within the Development Envelope abstract from the Leederville Aquifer (eight licenses). There are also 26 current and legacy landholder bores within the Development Envelope which are screened within the Superficial Aquifer but not licenced. Licencing of Superficial Aquifer abstractions are not always mandated by the DWER.

GROUNDWATER DEPENDANT ECOSYSTEMS

The National Water Commission, in conjunction with State and Territory water agencies, maintains a database of GDEs for the purposes of environmental planning and ecosystems management. The database includes three categories: cave ecosystems, including stygofauna; terrestrial GDEs, such as terrestrial vegetation; and aquatic GDEs, such as wetlands and springs.

A search of the database by HydroSolutions (2017) over a 5km radius from the Site indicated that no stygofaunal GDEs were present in the vicinity of the Site, but that the surrounding area contains marri, jarrah, wandoo, river gum and casuarina vegetation, identified in the database as "medium woodland" with moderate to high potential GDE status. The majority of these stands of vegetation are proximal to the Sabina River.

A Level 1 Flora and Vegetation Survey has been undertaken by Ecoedge (2016), which concluded that it is likely much of the native vegetation on Site are potential terrestrial GDEs, and that further detailed studies are required to identify at-risk populations. This is compatible with observations that the water table is relatively shallow at several locations on Site.

Due to the scope and timing of the Flora and Vegetation Survey, a detailed review of soil information from existing exploration drilling/assay data, depths to groundwater and proposed dewatering extents, and specific groundwater dependence of on-Site vegetation was not able to be undertaken. However, an initial assumption is that mapped vegetation present above a water table at <3mBGL may be potential GDEs (the depth of 3m is considered to be the normal limit for the evapotranspiration extinction depth in groundwater modelling). As shown in Figure 6-4, with the exception of a small area in the central south, the entire Site is located above a water table shallower than 3mBGL.

DBCA's Geomorphic Wetlands Swan Coastal plain dataset displays the location, boundary, wetland type and management category of wetlands on the Swan Coastal Plain. A review of this dataset by HydroSolutions (2017) indicates that the Site and area surrounding the Site is generally designated as a palusplain (i.e. flat, seasonally waterlogged wetlands) with isolated floodplain areas, damplands and sumplands (the latter two referring to groundwater-receiving seasonal depressions). All wetlands within 5km of the Site have been categorised for management as "Multiple Use" which is defined as "wetlands with few remaining important attributes and functions".

Three reserve areas in the Busselton-Capel groundwater subarea are under ecological monitoring due to the presence of high sensitivity GDE's (DoW, 2009). These GDE's have management triggers and responses attached to them by DWER (Del Borello, 2008). These are labelled 'conservation' sumplands and floodplains, but are located approximately 6km to either the northeast or southwest of the Development Envelope and will therefore not be affected by the Proposal.

ACID SULFATE SOILS

Doral undertook a targeted ASS investigation in conjunction with resource definition drilling at the Site in mid-December 2014 to assist in determining the presence and distribution of ASS at the Site and also to characterise the various geological/geomorphological units.

The Site occurs in an area depicted on an ASS risk map as Class II 'moderate to low risk of ASS occurring within 3m of natural soil surface' and is shown as being underlain by Pliocene to Quarternary sands and silts, which comprise the Superficial Formations. Identified units within the Superficial formations include Bassendean Sand (aeolian quartz sand), the Guildford Formation (dominated by interbedded sandy silt in the area) and the Yoganup Formation (fine to medium quartz sand). The total depth of the superficial formations at the Site is approximately 12-15m.

Field results of the ASS investigation indicate that Site soils are generally slightly acidic to neutral as a large proportion of pH_F results are within the pH6.0 to pH7.0 range. This indicates that there is very little actual acidity present in the soil profile, which is confirmed by the laboratory results, which show very little acidity is present as s-TAA (i.e. actual acidity). However, field results also show a high proportion of samples with $pH_{FOX} \leq 3$ and a ΔpH above 3.0pH units, indicating that there is additional potential acidity within the soil profile. This is also confirmed by the laboratory chromium reducible sulfur (CRS) results which show 49 of the 75 samples analysed, contain net acidity (NA) as S_{CR} above the DWER action criterion (0.03%S).

Elevated NA above the action criterion was generally identified at depth (i.e. greater than ~5mBGL) from 10 of the 11 locations and at three of these locations elevated NA was also identified in surface and near surface soils. It should be noted however that 41 of the 75 samples analysed by CRS were located >1m below the maximum depth of mine pits, of which 33 exceed the action criterion. The remaining 34 samples analysed for NA were located from soils within the ore zone of the proposed mine pits, of which 16 exceeded the NA action criterion. Limited sampling was undertaken within the top 5m of the soil profile. Further investigations (predominantly of surface and overburden soils) are planned for late 2017.

ASS is discussed further in Section 8 – Terrestrial Environmental Quality.

SURFACE WATER

Local Rivers

The Site is within the Wonnerup (Busselton Coast) Surface Water Management subarea (Figure 6-1) and is not within a proclaimed area for surface water management (DoW, 2009).

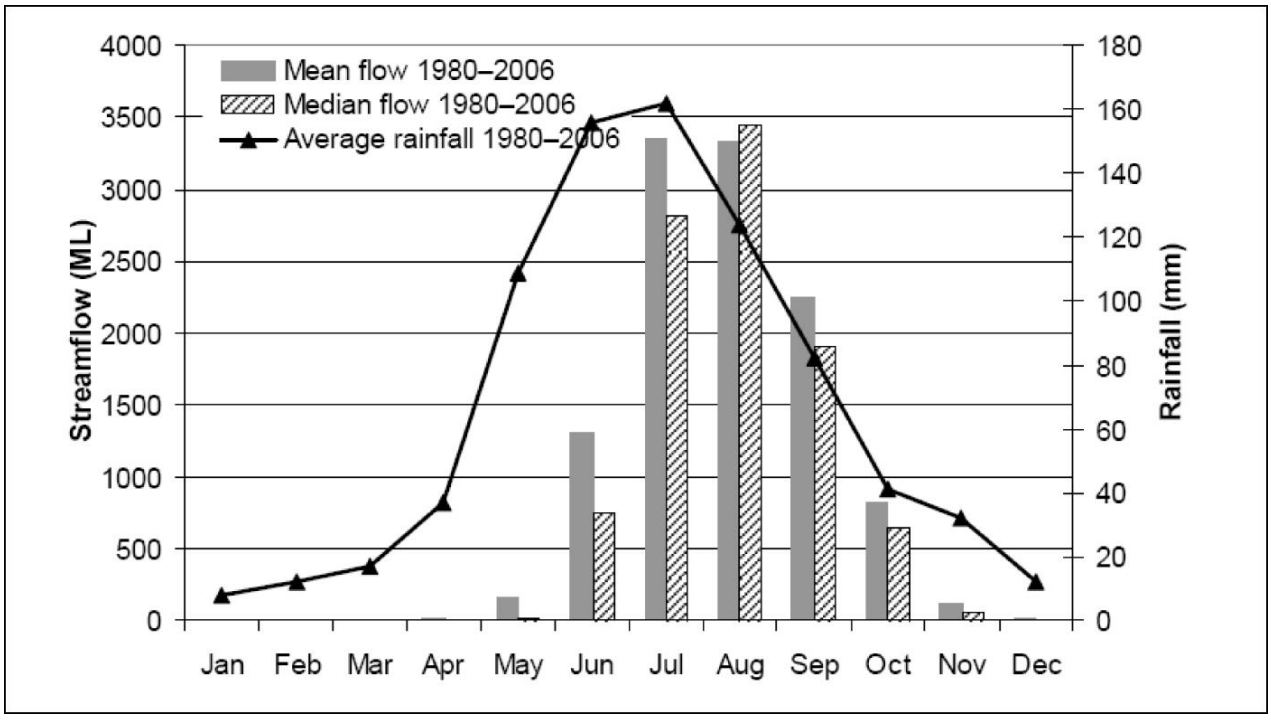
The Sabina and Abba Rivers are located within 1km of the Site to the southwest and northeast, respectively. The Sabina River has been heavily modified, with flow from the upper reaches of the Sabina River (i.e. Upper Sabina River) being diverted to the Sabina River Diversion Drain, approximately 1.5km west of the Site. The Sabina River Diversion drain joins the Vasse Diversion drain to the northwest of the Site, which was constructed in 1927 to divert ~65% of flow from the Sabina River and 90% of flow from the Vasse River away from the Lower Vasse River and the Vasse Wonnerup wetlands.

The Lower Sabina River (i.e. below the diversion) and Abba River flow generally to the northwest of the Site and discharge into the Vasse-Wonnerup wetlands, approximately ~4.6km to the north-northwest of the Site (Figure 1-1). The Lower Sabina River has a total catchment area of 49km^2, while the Abba River has a total catchment area of 261km^2.

The major drainage features and catchment areas relevant to the Site are shown on Figure 6-5. These show that the Site is likely to be located wholly within the Sabina River catchment area, however, available regional mapping indicates that the north-eastern corner may straddle the catchment divide with the Abba River, although no evidence of surface water flows draining towards the Abba River were observed during the HydroSolutions (2017) site visit. Furthermore, the Princefield Road drain diverts runoff towards the Woddidup Creek and eventually to the Lower Sabina River. Previous high rainfall had led to surface water run-off observed within the shallow field drains on the western and northern Site boundaries, with flow observed to be occurring to the north and west respectively towards the tributary of the Lower Sabina River.

There is no river gauging station within the Lower Sabina River, however DWER has modelled monthly flows based on average monthly rainfall from 1980-2006 (DoW, 2010) as shown in Chart 1. Flow in the Lower Sabina River is seasonal, typically occurring between May and October and based on the flow modelling, has an average annual discharge of approximately 11GL (DoW, 2010). The Whicher Area Surface Water Management Plan (DoW, 2009) does not list the Sabina or Abba Rivers as connected to the groundwater system (as opposed to the Capel or Margaret Rivers). Hydrographs for the Abba River (refer to Appendix 3 of HydroSolutions, 2017) and DWER modelling for the Lower Sabina River (Chart 1) (DoW, 2010) indicate a clear cease to flow levels during a substantial part of the summer low-rainfall period, which suggests that there is limited or no groundwater contribution to surface water flow (i.e. as baseflow discharge) in the rivers. The surface water flow regime is therefore likely to be dominated by high-rainfall periods generating surface water run-off, rather than any substantial groundwater flow component.

CHART 1: LOWER SABINA RIVER MODELLED MONTHLY FLOW AND AVERAGE RAINFALL 1980-2006 (DoW, 2010)



On-Site Drainage

Numerous farm/field drains exist on Site, with three main drains identified in June 2017 to assist with background surface water sampling. These include one drain extending along the western boundary of the Site ('Wonnerup Road South Drain') and a further two located in the western-central parts of the Site (Woddidup Creek/Drain), which are adapted from ephemeral creeks (Figure 6-5). These flow generally towards the north and northwest, and join the Lower Sabina River approximately 2km downstream at Wonnerup South Road. A discontinuous road-side drain is located along the northern boundary of the Site following Princefield Road, which flows to the west to join the Woddidup Creek/Drain draining to the north towards the Lower Sabina River.

Inspection of the Site by HydroSolutions (2017) confirmed that these drains have maximum depths of <1 m across the Site. Given that some static groundwater levels on Site have been reported to be very shallow (i.e. eight wells in the area contained water levels at <2mBGL), it is possible that these drains are connected to groundwater periodically. However, it should be noted that groundwater levels in the vicinity of the drains are generally >2mBGL except in the far southeast corner of the Site, and that any groundwater baseflow discharge to surface water flow in the drains would therefore be expected to be limited (or periodically absent).

VASSE – WONNERUP RAMSAR WETLAND

The RAMSAR listed Vasse-Wonnerup wetland, ~4.6km to the northwest of the Site (Figure 1-1), receive inflow from the Vasse, Sabina, Abba and Ludlow rivers, a total catchment area of approximately 961km^2. The Vasse-Wonnerup system is already highly hydrologically and chemically altered due to extensive clearing, agricultural practices occurring over most of the Geographe catchment, and other commercial and residential developments in the area. Clearing and agricultural practices contribute to altered water regimes and increases in nutrients, sedimentation and pollution (DoW, 2010). The system is highly modified, with diversion of flow from several of the rivers into the ocean that historically flowed into the Vasse and Wonnerup estuaries, which has accounted for a significant decrease in water entering the system. The floodgates were installed in the early 1900s to mitigate flooding of adjoining agricultural land during high river flows in winter and to prevent seawater inundation caused by storm surges. The gates effectively transformed the estuaries in to shallow, winter fresh/ summer saline lagoons, unique in Western Australia (Department of Environment, 2007). DWER estimated a 60% decrease in flow from the Sabina River and a 90% decrease from the Vasse River into the Wonnerup estuary as a result of these diversions (DoW, 2010).

The wetlands are listed as a wetland of International importance under the RAMSAR Convention. The high ecological values of the wetlands are coupled with extremely poor water quality in late summer that lead to fish kills and declines in visual amenity. The wetlands are managed for multiple purposes including water bird habitat, flood and storm surge mitigation, visual amenity and the prevention of fish kills.

Department of Environment (2007) reported that the wetlands are subject to poor water quality issues, with the floodgates acting to reduce flushing flows that may otherwise help to ameliorate high nutrient concentrations from catchment runoff, while excessive algal blooms, blooms of potentially toxic cyanobacteria and fish deaths are not uncommon (and) increased salinisation of adjoining pastoral lands and death of colonising native vegetation.

6.5. POTENTIAL IMPACTS

Potential impacts from the Proposal on hydrological processes are:

- Short-term dewatering of mine pits and associated drawdown of the water table, which may affect:
    - Water availability at surrounding groundwater users;
    - Potential GDE's;
    - Acid Sulfate Soils;
    - Surface water courses.
- A reduction in surface water yield in the Lower Sabina River sub-catchment;
- Hydrological impacts on the Vasse-Wonnerup System RAMSAR Wetland;
- Short-term abstraction of water from the Yarragadee aquifer, which may affect other users of the Yarragadee aquifer and the overlying Leederville Aquifer.

6.6. ASSESSMENT OF IMPACTS

DEWATERING MINE PITS AND DRAWDOWN OF WATER TABLE

Dewatering of mine pits and localised drawdown of the water table will occur in a staged approach, with mine 'blocks' being dewatered as per the mining schedule (TBC). Dewatering involves lowering the hydraulic head of the aquifer to the base of the open-cut mine pit, to allow dry mining techniques to be carried out within the pit. However, it should be noted that the process water storage dams and tailing activities can quickly counteract this drawdown to some extent within the Development Envelope. Process water storage dams can act to raise aquifer levels in localised areas and tailing into recently mined areas rapidly reinstates the localised drawdown of the Superficial Aquifer.

Dewatering of mining areas occurs through the construction of a sump at the deepest point of the pit. The rest of the pit is then open drained to this sump with water is pumped from the sump to the drop out dam (either directly or via an open drain and then gravity fed). Water then flows from the drop out dam to the PWP, where it is utilised in processing operations.

To assist in determining dewatering requirements including the extent and possible impacts from dewatering, HydroSolutions (2017) prepared an initial groundwater model. It should be emphasised that this model is very preliminary and based on numerous assumptions. The preliminary modelling does not account for recharge from tails water recharge. More accurate modelling will be undertaken in due course as new data becomes available. The initial modelling indicates the following predicted drawdown extents as shown on Figures 6-6 to 6-11:

- No mining related drawdown in the Leederville or Yarragadee Aquifer's are predicted;
- Within the Superficial Aquifer:
    - The predicted 0.1m drawdown contour may extend between 95m and 1,083m from the mine pits;
    - The predicted 1m drawdown contour may extend between 560m to 670m from the mine pits;
    - The predicted 5m drawdown contour may extend between 90m and 300m.

It should be noted that no modelling of drawdowns for the abstraction of water from a proposed Yarragadee production well has been undertaken to date. Further information in relation to the abstraction of water from the Yarragadee Aquifer will be provided when available.

DRAWDOWN ON GROUNDWATER USERS

Of the 65 licenced bores located within a 5km radius of the Site, all but three are screened within the Leederville or Yarragadee Aquifers. As the initial dewatering modelling indicates that dewatering drawdown will only affect the Superficial Aquifer, assuming the aquitard layer of the Leederville Aquifer remains intact, 62 of these bores will be unaffected by mining related dewatering. The remaining three licenced bores screened within the Superficial Aquifer are located outside of the predicted 0.1m drawdown contour and will also not be affected by Site dewatering activities.

On the basis of the initial dewatering drawdown extents however, drawdown is likely to affect some local on-site bores (unlicensed) which access the Superficial Aquifer. The degree of impact is related to the distance from the operationally dewatered area (i.e. mine void), with water table level reductions estimated to be in the order of 1m at approximately 560 to 670m, and of 5m at approximately 90 to 300m distances from the segment being mined at any one time. Many of these superficial bores are decommissioned installations that have been superseded by adjacent Leederville Aquifer bore pumps. Superficial Aquifer bores identified by HydroSolutions (2017) as likely to experience water level reductions are shown in Table 6-1. Only one of the listed sites supplies a house (well 20005166: non-potable water) with the remainder of active sites being used for livestock water only.

TABLE 6-1: ON-SITE SUPERICIAL AQUIFER BORES WITH POTENTIALLLY REDUCED GROUNDWATER LEVELS

YEAR	ESTIMATED DRAWDOWN (M)	BORE NAME	EASTING (GDA94)	NORTHING (GDA94)	OWNERSHIP	USAGE
2021	0.1-1	20005165	357282	6270170	Private, lot 843	Disused
		20005167	356360	6270395	Private	Disused
		20005168	355790	6271295	Private, lot 971	
2022	0.1-1	20005169	356737	6271639	Private, lot 229	
		20005101	358052	6272283	Private, lot 104	
		20005114	358644	6270521	Private, lot 1426	Disused
		20005165	357282	6270170	Private, lot 843	Disused
2023	0.1-1	20005101	358052	6272283	Private, lot 104	
		20005115	357995	6269748	Private, lot 668	Disused
		TS012S	358329.55	6270016.58	Private, lot 1426	Disused
		20005111	358054	6270091	Private, lot 758	Disused
		20005114	358644	6270521	Private, lot 1426	Disused
	1-5	20005167	356360	6270395	Private.	Anecdotally due to be decommissioned
		20005171	356627	6269888	Private, lot 421.	Disused
		LOT421_BORE2	356993	6269791	Private, lot 421	
		20005165	357282	6270170	Private, lot 843	Disused
		20005166	357402	6269919	Private, lot 421	
	5-10	SCPD28A	358612	6271752	Department of Water	
		20005171	356627	6269888	Private, lot 421.	Disused
		20005167	356360	6270395	Private.	Anecdotally due to be decommissioned
		20005169	356737	6271639	Private, lot 229	
		SCPD28A	358612	6271752	Department of Water	

YEAR	ESTIMATED DRAWDOWN (M)	BORE NAME	EASTING (GDA94)	NORTHING (GDA94)	OWNERSHIP	USAGE
2024		20005114	358644	6270521	Private, lot 1426	Disused
		20005115	357995	6269748	Private, lot 668	Disused
		TS012M	358329.71	6270015.68	Private, lot 1426	Disused
		20005111	358054	6270091	Private, lot 758	Disused
		LOT421_BORE2	356993	6269791	Private, lot 421	
	1-5	20005114	358644	6270521	Private, lot 1426	Disused
		LOT1464_WELL	359520	6270925	Private, lot 1464	Disused
		20005101	358052	6272283	Private, lot 104	
2025	0.1-1	20005114	358644	6270521	Private, lot 1426	Disused
		LOT1464_WELL	359520	6270925	Private, lot 1464	Disused
		20005101	358052	6272283	Private, lot 104	
	1-5	None				
	5-10	SCPD28A	358612	6271752	Department of Water	
2026	0.1-1	20005165	357282	6270170	Private, lot 843	Disused
		20005166	357402	6269919	Private, lot 421	
		TS012S	358329.55	6270016.58	Private, lot 1426	Disused
		20005115	357995	6269748	Private, lot 668	Disused
		20005111	358054	6270091	Private, lot 758	Disused
		LOT1464_WELL	359520	6270925	Private, lot 1464	Disused
		20005101	358052	6272283	Private, lot 104	
	1-5	SCPD28A	358612	6271752	Department of Water	
		20005114	358644	6270521	Private, lot 1426	Disused

DRAWDOWN OF POTENTIAL GDE'S

Due to the scope and timing of the Flora and Vegetation Survey, a detailed review of soil information from existing exploration drilling/assay data, depths to groundwater and proposed dewatering extents, and specific groundwater dependence of on-Site vegetation was not able to be undertaken, however Ecoedge (2016) noted that the majority of vegetation present within the Development Envelope contain species that are associated with wetland vegetation and are potentially phreatophytic.

Therefore, an initial assumption to assist with determining potential impacts is that mapped vegetation present above a water table of <3mBGL may be potential GDEs (the depth of 3m is considered to be the normal limit for the evapotranspiration extinction depth in groundwater modelling). As shown in Figure 6-4, with the exception of a small area in the central south, the entire Site is located above a water table shallower than 3 mBGL.

Initial drawdown modelling (although preliminary) indicates that a drawdown of up to 1m may be expected to occur within approximately 560 to 670m of mine pits, which would result in a reduction to groundwater levels and therefore access to groundwater for potential GDEs within the Development Envelope. Further detailed modelling of dewatering drawdowns, assessment of soil profiles and identification of GDE's is required to determine the actual impact on GDEs.

DRAWDOWN ON POTENTIAL ASS

Results of Doral's ASS investigation indicate that potential unoxidised sulfidic acidity is present in Site soils. If exposed to the atmosphere, the sulfide minerals will oxidise and generate sulfidic acidity. Oxidation of sulfide minerals may potentially occur during extraction of soils containing potential ASS and/or as a result of dewatering activities. It should be noted that this section only considers the potential impacts of residual *in situ* ASS exposed to oxidation by dewatering and does not consider the fate of ASS material removed as overburden or for processing as ore (refer to Section 8).

Dewatering to the required depth of excavation (maximum of ~12mBGL) will occur passively as groundwater enters the mining excavation. The water will be pumped out using a suction pump set at a level to maintain a 0.5m saturated pit floor and sent through to a sump prior to reaching the unlined process water pond where it mixes with other water from other mine processes. This lowering of the water table (although passive) may therefore expose sulfide minerals to oxygen, resulting in oxidation of *in situ* soils within the predicted dewatering drawdown extent. If the oxidation of *in situ* ASS generates sulfidic acidity then groundwater is the initial pathway by which impacts may migrate. Acidity could therefore be mobilised downwards by leachate, upwards with groundwater rebound, or laterally by groundwater migration. If acidic groundwater mobilises heavy metals they will migrate along the same pathways.

DRAWDOWN ON SURFACE WATER COURSES

Initial drawdown modelling by HydroSolutions (2017) shows the drawdown from dewatering of mine pits does not extend to the Lower Sabina River, however the 0.1m contour (based on preliminary modelling) does extend to the Abba River in 2025 and 2026 (Figures 6-10 and 6-11). The Whicher Area Surface Water Management Plan (DoW, 2009) does not list the Sabina or Abba Rivers as being connected to the groundwater system (as opposed to the Capel or Margaret Rivers for example). Notwithstanding, the shallow depth of unconfined groundwater at the Site could suggest the possibility of groundwater discharge occurring as base flow as a component of flow in these rivers.

DWER modelling for the Lower Sabina River (Chart 1) (DoW, 2010) and hydrographs for the Abba River (refer to Appendix 3 of HydroSolutions, 2017) indicate a clear cease to flow levels during a substantial part of the summer low-rainfall period, which suggests that there is limited or no groundwater contribution to surface water flow (i.e. as baseflow discharge) in the rivers. The surface water flow regime is therefore likely to be dominated by high-rainfall periods generating surface water run-off, rather than any substantial groundwater flow component. As such, dewatering for the Proposal is unlikely to affect the Sabina or Abba River's.

REDUCTION IN SURFACE WATER YIELD

The Development Envelope is located within the catchment of the Lower Sabina River and will have little influence over the ~3km stretch of the river from the Sabina Diversion Weir to the Woddidup confluence. Based on a catchment area of 49km^2 for the Lower Sabina River and a total mine pit disturbance area of ~0.3km^2, the maximum reduction to the Lower Sabina River catchment is calculated to be ~0.6%. However, it should be noted that as mining is staged and not all mine pits will be open at once to capture rainfall/runoff, the actual reduction to the catchment area will be less than 0.6%. Furthermore, given that DWER flow modelling (Chart 1) (DoW, 2010), indicates the Lower Sabina River has an average annual discharge of approximately 11GL, disturbance of up to 0.6% of the catchment area would only reduce the annual discharge by 0.66GL.

HYDROLOGICAL IMPACTS ON THE RAMSAR LISTED VASSE-WONNERUP WETLAND

Hydrological impacts to the RAMSAR listed Vasse-Wonnerup wetland, located ~4.6km northwest of the Site, may occur as a result of changed surface water flows, increases in sedimentation and/or reduction in water quality, thereby reducing the ecological function of the wetland. However, as the catchment of the Vasse-Wonnerup wetland covers a total area of 961km^2 and the total mine pit disturbance area is ~0.3km^2 (not accounting for staged mining), only 0.03% of the catchment area will potentially be affected by the Proposal.

Initial drawdown modelling also indicates that the maximum extent of mining related drawdown (0.1m contour) may extend up to 1,083m from the mine pits. As the Vasse-Wonnerup wetland is located ~4.6km northwest of the Site, no impacts from drawdown are expected.

Potential impacts resulting from sedimentation and reduction in water quality are further discussed in Section 7.

SHORT-TERM ABSTRACTION OF WATER FROM THE YARRAGADEE AQUIFER POTENTIALLY AFFECTING OTHER USERS OF THE YARRAGADEE AQUIFER

No modelling has currently been undertaken to determine whether abstraction of water from the Yarragadee aquifer will affect the eight known Yarragadee users within 5km of the Site.

6.7. MITIGATION

The key mitigation measures to reduce impacts to hydrological processes are:

- Preparation and implementation of plans and procedures relevant to the management of groundwater and surface water (including monitoring programs, trigger criteria, management responses and contingencies);
- Preparation and implementation of an ASSMP in consultation with DWER (refer to Section 8);
- Supply affected bore owners with supplementary water (where required);
- Pits will be backfilled as soon as possible following cessation of mining to assist in recovery of groundwater levels as soon as possible;
- Groundwater monitoring bores and soil moisture bores will be installed around conservation significant GDE's and monitored for changes in groundwater levels and soil moisture content.
- Placement of production bores to avoid impacts to other Yarragadee aquifer users as far as practicable;
- Volumes of water abstracted from the Yarragadee aquifer will be recorded monthly;
- Reporting in accordance with conditions of the approvals documents (Ministerial Statement, RIWI Act licences, DWER Licence to Operate etc.).

6.8. PREDICTED OUTCOME

The predicted outcomes after the application of the mitigation measures are:

- No mining related drawdown in the Leederville or Yarragadee Aquifers is predicted based on preliminary modelling.
- Within the Superficial Aquifer, the following drawdowns may occur:
    - The 0.1m drawdown contour may extend between 95m and 1,083m from the mine pits;
    - The 1m drawdown contour may extend between 560m to 670m from the mine pits;
    - The predicted 5m drawdown contour may extend between 90m and 300m.
- Several bores screened within the Superficial Aquifer may be affected by groundwater drawdowns (based on preliminary modelling only). Many of these bores are disused or decommissioned, and all but one are used for livestock water only. The remaining bore (20005166) supplies a house with

non-potable water. Impacts will be mitigated by the supply of supplementary water to meet the needs of the bore owners.

- Groundwater drawdowns may lead to reduced access to groundwater for potential GDEs within the Development Envelope, however further detailed modelling of dewatering drawdowns, assessment of soil profiles and identification of GDE's is required to quantify impacts to GDEs.
- Lowering of the water table (although passive) may expose potential ASS to oxygen, resulting in oxidation of *in situ* soils within the predicted dewatering drawdown extent.
- No adverse impacts to the Lower Sabina River, Abba River or Vasse-Wonnerup wetland area are predicted from groundwater drawdowns.
- Minimal reduction to surface water yields in the Lower Sabina River and Vasse-Wonnerup wetlands are predicted due to the small area of open mine pits intercepting rainfall/runoff.

Doral expects that with the implementation of the mitigation measures described above, it is likely the EPA's objective to maintain the hydrological regimes of groundwater and surface water so that environmental values are protected, can be achieved.

7. INLAND WATERS ENVIRONMENTAL QUALITY

For the purposes of EIA, the EPA defines the factor Inland Waters Environmental Quality as:

> *The chemical, physical, biological and aesthetic characteristics of inland waters.*

7.1. EPA OBJECTIVE

The EPA objective for Inland Waters Environmental Quality is:

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

The objective recognises the fundamental link between water quality and the environmental values supported by good water quality. It also recognises the principle of waste minimisation of the EP Act. Water quality can be impacted by both direct discharge of waste and diffuse sources of pollution associated with catchment land uses.

EPA's focus of this factor and its associated objective as described in EPA (2016e) is:

- How the discharge of waste is minimised;
- How any discharge of water or use of land or water will significantly impact on water quality and the environmental values its supports.

7.2. POLICY AND GUIDANCE

- *Environmental Factor Guideline – Inland Waters Environmental Quality* (EPA, 2016e)

7.3. CONSULTATION

Consultation will be undertaken with:

- DWER;
- DoEE;
- Other interested parties.

7.4. RECEIVING ENVIRONMENT

INVESTIGATIONS UNDERTAKEN

HydroSolutions (2017) undertook an initial hydrogeological desktop assessment for the Proposal (Appendix 2). The assessment included the identification of environmental values and beneficial uses of water which have the potential to be impacted by the Proposal and a preliminary assessment of groundwater and surface water quality in the vicinity of the Site.

ENVIRONMENTAL VALUES AND BENEFICIAL USES

Environmental value is defined under the EP Act as a beneficial use or an ecosystem health condition (EPA, 2016e). In relation to ecosystem health, the EPA is focused on impacts to environmentally significant ecosystems. These include:

- Wetlands which are RAMSAR listed, Conservation Category, or listed in the Directory of Important Wetlands in Australia;

- Wild and scenic rivers;
- Poorly represented wetland types;
- Natural springs and pool, particularly in arid areas;
- Ecosystems which support conservation significant flora/vegetation and fauna species or communities, including migratory waterbirds and subterranean fauna.

For beneficial uses, the EPA is focused on significant beneficial uses such as:

- Drinking water supplies;
- Water supplies which support significant non-potable use and commercial activities;
- Inland waters with high levels of active and passive recreation;
- Inland waters with significant cultural and aesthetic values.

Environmental values considered relevant to the Proposal include the following:

- RAMSAR listed Vasse-Wonnerup wetlands;
- Lower Sabina River;
- Groundwater which may be abstracted for livestock and non-potable uses.

A description of the receiving environment relevant to inland waters environmental quality is provided in Section 6.4 which includes a description of the following:

- Groundwater management areas and hydrogeology;
- Groundwater users;
- Surface water regimes including the Lower Sabina River and drainage network;
- RAMSAR listed Vasse-Wonnerup wetlands.

BACKGROUND GROUNDWATER QUALITY

Doral recognise the importance of the collection of background or 'pre-mine' water quality data given the wider Busselton area has previously been modified by agricultural uses since the 1830s (DoW, 2010) and has the potential to be further impacted by mining. Background groundwater quality data will be used for comparison with data collected during mining and post-mining to monitor and identify any impacts.

Due to the preliminary nature of the Proposal, Doral are yet to install site-specific groundwater monitoring wells to commence the collection of background groundwater data (quality and levels) in either the Superficial and Leederville aquifers. Installation of these monitoring wells is planned to occur in late 2017. A network of landowner and/or DWER bores however have been used to collect initial samples to assist in assessing the baseline quality of groundwater from the Superficial Aquifer.

Hirschberg (1987) notes that the regional groundwater quality of the Superficial Aquifer in proximity to the Proposal contains low salinities (<300 mg/L TDS), neutral to slightly acidic pH (5.9 to 7.3pH), low alkalinity (<30 mg$CaCO^3$/L), with dominant ions of sodium and chloride. Hirschberg (1987) comments that the percentages of the major ions are similar from practically all bores within his study area (Bunbury to Dunsborough) indicating a close relationship between the different aquifers.

HydroSolutions (2017) assessed available groundwater quality data for bores screened within the Superficial Aquifer. These results have been collated and compared to relevant guidelines and are included in Appendix 4 of HydroSolutions (2017). Bores exceeding these criteria are as follows:

- Bores SCPD28A and 20005166 exceed the DWER Fresh Water Guidelines for:
    - Aluminium;
    - Zinc.
- Bores SCPD28A exceeds the ANZECC (2000) Nutrient Guidelines for SW Australian lowland rivers for:
    - Total Phosphorous.
- All bores exceed the ANZECC (2000) Nutrient Guidelines for SW Australian lowland rivers for:
    - Total Nitrogen.
- Bore TS012M exceeds the DWER Fresh Water Guidelines and the ANZECC (2000) Nutrient Guidelines for SW Australian lowland rivers for:
    - Ammonia (NH_3 as N).

Doral will continue to assess groundwater quality from both the Superficial and Leederville Aquifer's and will be included in future environmental approval documentation, as required.

BACKGROUND SURFACE WATER QUALITY

Doral has a dedicated surface water monitoring program in place and has recently commenced sampling at 14 locations as shown on Figure 6-5. The sampling locations comprise both on-site farm dams, field drains and creeks. These results have been collated and compared to relevant guidelines and are included in Appendix 4 of HydroSolutions (2017). Locations exceeding guideline criteria are as follows:

- YALSW04 exceeds the ANZECC (2000) Nutrient Guidelines for South West Australian Lowland Rivers for:
    - Total Nitrogen;
    - Ammonia (NH_3 as N).
- YALSW04 and YALSW07 exceed the DWER Fresh Water Guidelines for:
    - Aluminium.

Locations YALSW05, YALSAW06, YALSW07, YALSW11 and YALSW13 are all above the EC and/or TDS limits for fresh water, although they are all in the transitional range, except YALSW07 which is brackish. HydroSolutions (2017) commented that this may not be unexpected in some surface sampling locations, given that many locations were not experiencing any flow during the time of sampling, as sampling occurred prior to the onset of winter rainfall.

7.5. POTENTIAL IMPACTS

Potential impacts from the Proposal on inland waters environmental quality are:

- Reduction in groundwater quality to the Superficial Aquifer as a result of dewatering potential ASS potentially affecting beneficial users of water such as livestock and non-potable uses;

- Reduction in surface water quality as a result of discharge of water in emergency situations, which may have a localised adverse effect on the receiving environment, such as the Lower Sabina River and the RAMSAR Vasse-Wonnerup wetlands.

7.6. ASSESSMENT OF IMPACTS

REDUCTION IN GROUNDWATER QUALITY

As discussed in Section 6.6, dewatering of the water table is required to facilitate dry mining techniques. Passive dewatering, by constructing a sump at the deepest point of the pit, will be undertaken in a staged approach. Preliminary dewatering modelling by HydroSolutions (2017) indicates that only the Superfical Aquifer will be affected by dewatering. No mining related impacts to the Leederville or Yarragadee Aquifers is expected.

Based on the results of Doral's ASS investigation (refer to Section 8), lowering of the water table (although passive) may potentially expose sulfide minerals to oxygen, resulting in some oxidation of *in situ* soils within the predicted dewatering drawdown extent. If the oxidation of *in situ* ASS generates sulfidic acidity then groundwater is the initial pathway by which impacts may migrate. Acidity could therefore be mobilised downwards by leachate, upwards with groundwater rebound, or laterally by groundwater migration. If acidic groundwater mobilises heavy metals they will migrate along the same pathways and have the potential to reduce the quality of bores screened within the Superficial Aquifer.

Although there are approximately 26 unlicenced bores screened within the Superficial Aquifer on-site, evidence suggests that many of these bores are disused or have been decommissioned. The remaining operational Superficial bores are used to abstract water from the Superficial Aquifer for predominantly livestock water and for domestic non-potable purposes (limited to one known bore), rather than drinking water purposes. Drinking water for residences in and around the Development Envelope is collected from rainwater tanks and/or abstracted from the Leederville Aquifer. All household bores use some degree of filtration circuit for iron and manganese. Leederville bores are unlikely to be affected by mining related drawdown and potentially reduced water quality.

Water availability in the on-site Superficial bores might be reduced for short durations during the dewatering activities. Doral will ensure an alternative option for livestock and/or domestic non-potable purposes during any dewatering period.

REDUCTION IN SURFACE WATER QUALITY FROM EMERGENCY DISCHARGE OF WATER

In the event of all water storages (i.e. mine voids, process water pond, drop-out pond, SEPs and drains) being at their full capacities and prolonged heavy rainfall occurs within the pit catchment area, excess water will have to be discharged offsite via a proposed controlled "Licensed Discharge Point". Any water that would be discharged off the mine site from the licenced discharge point could include a mixture of groundwater, surface inflow, direct rainfall, SEP and sand tails returns and surface runoff collected from the mine site.

The volume of water being discharged from the mine site will vary depending on the capacity of the process water pond and return water lines at the time of the rainfall event, and depending on the amount of water required to be discharged at that time. Discharge of water will not occur until strict water quality criteria are met as per the DWER licence conditions. V-notch flow gauges will be installed at the proposed Licence Discharge Point. Once discharged, water will move through the on-site drainage network (i.e. field drains south of Princefield Road) prior to reaching Woddidup Creek/drain (at Princefield Road). From there it will flow towards the Lower Sabina River northwest of the mine where it will ultimately discharge into the Vasse-

Wonnerup wetlands. The discharged water will mix with other water in the Lower Sabina River catchment and given that water will only be discharged from the mine site during periods of heavy rainfall when all water storages are full (i.e. emergency situations only), discharge is likely to coincide with seasonal higher flows of the Lower Sabina River catchment. Any discharge from the mine site is likely to be only a very small percentage of this volume.

7.7. MITIGATION

The key mitigation measures to reduce impacts to hydrological processes are:

- Preparation and implementation of plans and procedures relevant to the management of groundwater and surface water (including monitoring programs, trigger criteria, management responses and contingencies);
- Preparation and implementation of an ASSMP in consultation with DWER (see Section 8);
- Increase buffering capacity of process water;
- Supply affected bore owners with supplementary water (where required);
- Volumes and quality of water discharged from the mine site will be recorded during emergency discharge events and managed in accordance with the Site's DWER Licence;
- Prevention/minimisation of erosion at the point of discharge from Site.

7.8. PREDICTED OUTCOME

Doral consider that with the implementation of the mitigation measures listed above, that the EPA's objective to maintain the quality of groundwater and surface water so that environmental values are protected, can be achieved.

8. TERRESTRIAL ENVIRONMENTAL QUALITY

For the purposes of EIA, the EPA defines the factor Terrestrial Environmental Quality as:

The chemical, physical, biological and aesthetic characteristics of soils.

8.1. EPA OBJECTIVE

The EPA objective for Terrestrial Environmental Quality is:

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

8.2. POLICY AND GUIDANCE

Guidance relevant to Terrestrial Environmental Quality that have been considered during the EIA process are documented in the following document:

- *Environmental Factor Guideline – Terrestrial Environmental* (EPA, 2016f).

8.3. RECEIVING ENVIRONMENT

INVESTIGATION UNDERTAKEN

Doral undertook a targeted soil investigation (Doral, 2017) in conjunction with resource definition drilling at the Site in mid-December 2014 to provide a preliminary understand of ASS at the Site (Appendix 3). The Site occurs in an area depicted on an ASS risk map as Class II 'moderate to low risk of ASS occurring within 3m of natural soil surface' (Figure 8-1) and is shown as being underlain by Pliocene to Quarternary sands and silts, which comprise the Superficial Formations. Identified units within the Superficial formations include Bassendean Sand (aeolian quartz sand), the Guildford Formation (dominated by interbedded sandy silt in the area) and the Yoganup Formation (fine to medium quartz sand). The total depth of the superficial formations at the Site is approximately 12-15m.

The objectives of the investigation were to:

- Conduct preliminary soil sampling to identify the presence or the absence of ASS in areas likely to be disturbed;
- Assess the net acidity (comprising both existing and potential acidity) of soil at locations where mining is likely to result in disturbance below the natural groundwater table;
- Assess the baseline quality of groundwater (from existing landowner and DWER bores) that will require dewatering;
- Provide appropriate management measures, where required.

METHODOLGY

Drilling was undertaken using an air core drill rig, with soil samples collected and logged by Doral at 1m intervals from 31 locations (Figure 8-2). The drilling locations were spaced approximately 320m along the strike of the two deeper strandlines and drill holes were located at 80-120m spacing's across the widths of the anticipated deeper ore zones. The depth of drilling at each location was targeted to approximately 2m deeper than the anticipated maximum depth of disturbance, with a maximum drilling depth of 13mBGL.

Following logging of the soil profile, soil samples were collected for initial screening via field testing (pH_F and pH_{FOX}). Samples were placed in clearly labelled snaplock bags with air excluded and placed in a 12V vehicle

freezer whilst on site, allowing the samples to be stored below 0°C. Engraved sample tag labels were also included with all soil samples in the event sample names rubbed off the ziplock bags in transit. The samples were initially analysed for pH_F at Doral's laboratory, prior to being stored in Doral's chest freezer (due to Christmas closure of the laboratory). All samples were then transported to the Australian Government National Measurement Institute laboratory for analysis of pH_{FOX} before being placed on cold storage at the laboratory pending decisions about further analytical analysis

SOIL ASSESSMENT CRITERIA

The ASS characteristics at the Site were compared with guidance criteria provided in DER (2015a).

Field Test Criteria

The results of field tests are considered to give an indication of which samples may represent ASS material. The DER recommend that soils which have low pH values (pH_F of $\leq$4, or pH_{FOX} of $\leq$3), or which exhibit a significant change in pH (ΔpH, as pHf – pHfox) may indicate a soil with ASS characteristics (DER, 2015a).

As such field test results were compared with the following criteria to identify potential ASS horizons:

- A pH_F of 4 or less;
- A pH_{FOX} of 3 or less;
- A change in pH value (ΔpH) of at least 3 units.

Laboratory (Net Acidity) Criteria

Net acidity (NA) results were calculated using the equations presented in *Acid Sulfate Soils Laboratory Methods Guidelines* (Ahern, et al., 2004). The NA is calculated as the sum of actual acidity and potential acidity, as well as retained acidity (for low pH samples) and is used to characterise the current state and acid producing potential of the soils. Acid neutralising capacity is not included in the net acidity calculations, consistent with DER (2015a) guidance.

Actual acidity is available for release into the environment in the short term and is represented by Titratable Actual Acidity (TAA) values, using the Chromium Reducible Sulfur (CRS) method, while potential acidity is represented by S_{CR} values. The pH_{KCl} of a sample is used to determine the net acidity equation, which varies for samples with alkaline pH (net acidity = potential acidity), near neutral pH (net acidity = actual + potential acidity), and acid pH (net acidity = actual + potential + retained acidity).

The NA results are compared to the DER (2015a) action criterion of 0.03%S (for projects where more than 1,000 tonnes of soil will be disturbed). If results exceed this criterion, it requires the preparation of an ASS Management Plan (ASSMP).

SOIL RESULTS

Field Results

Field test results are summarised as follows:

- Field pH (pH_F) values range between 5.14 and 7.47.
- Field pH peroxide (pH_{FOX}) values range between 1.50 and 6.90.
- The change in pH (ΔpH) ranges between -0.23 and 5.05, with an average of 3.02.

Comparison to the DER (2015a) field test criteria for all 302 primary field tests indicates the following:

- 0 primary samples with a pH_F <4 were identified;
- 120 primary samples (~40% of all samples) with a pH_{FOX} <3 were identified;
- 142 primary samples (~47%) with ΔpH of three or greater were identified.

A significant fraction of samples would be considered to represent ASS material on the basis of the field test indicator values.

Laboratory (Net Acidity) Results

A total of 75 primary samples (~25% of total samples) were analysed via the CRS suite method from samples collected from 11 investigation locations. Samples were selected based on the field test results. The results of the laboratory CRS analyses are summarised as follows:

- One sample contained actual acidity (as s-TAA) in excess of the 0.03%S action criterion;
- 49 samples contained potential acidity (as S_{CR}) equal to or greater than the 0.03%S action criterion.
- Using the standard net acidity equation, NA values range from <0.01%S to 2.535%S.

Comparison of the CRS results to the assessment criteria indicates the following:

- 49 of the 75 samples analysed contained NA in excess of the 0.03%S action criteria.

Based on the calculated NA values, using the appropriate NA equation on the basis of the pH_{KCl} results, there are a total of 49 samples (65%) which exceed the 0.03%S NA action criterion, with values ranging from 0.03%S to 2.535%S. The maximum actual acidity (as s-TAA) is 0.035%S, and the maximum potential acidity (as S_{CR}) is 2.5%S. The maximum NA calculated from the CRS results is 2.535%S, with an average NA of 0.21%S for samples exceeding the DER (2015a) NA action criterion.

Summary of Soil Results

Field results indicate that Site soils are generally slightly acidic to neutral as a large proportion of pH_F results are within the pH6.0 to pH7.0 range. This indicates that there is very little actual acidity present in the soil profile, which is confirmed by the laboratory results, which show very little acidity is present as s-TAA. However, field results also show a high proportion of samples with $pH_{FOX} \leq 3$ and a ΔpH above 3pH units, indicating that there is additional potential acidity yet to be released into the soil profile. This is also confirmed by the laboratory CRS results which show 49 of the 75 samples analysed, contain NA as S_{CR} above the action criterion (0.03%S).

Elevated NA above the action criterion was generally identified at depth (i.e. greater than ~5mBGL) from 10 of the 11 locations and at three of these locations elevated NA was also identified in surface and near surface soils. It should be noted that 41 of the 75 samples analysed by CRS were located >1m below the maximum depth of mine pits, of which 33 exceed the action criterion. The remaining 34 samples analysed for NA were located from soils within the ore zone of the proposed mine pits, of which 16 exceeded the NA action criterion.

Doral is proposing to undertake further targeted ASS investigations in late 2017, to provide more information about the quality of soils predominantly in the overburden horizon to assist with refining the soil management strategy.

Groundwater Quality

Due to the preliminary nature of the Proposal, Doral are yet to install site-specific groundwater monitoring wells to commence the collection of background groundwater and data (quality and levels) in either the Superficial and Leederville aquifers. Installation of these monitoring wells is planned to occur in late 2017. However, a network of landowner and/or DWER bores have been used to make an initial assessment of the quality of groundwater in respects to ASS using guidance criteria in *Treatment and Management of soil and water in acid sulfate soil landscapes* (DER, 2015b) (refer to Doral, 2017, Appendix 3 for results).

Groundwater results from the initial groundwater monitoring undertaken by Doral, indicate that Superficial groundwater quality beneath the Site is slightly acidic due to pH levels generally <6.0 (although above the ASS indicator value of pH5.0), elevated total acidity concentrations of up to 110mg$CaCO_3$/L and moderate total alkalinity concentrations. The alkalinity/sulfate ratio indicates that groundwater is being affected by, or has already been affected by, the oxidation of sulfides. Moderate alkalinity concentrations coupled with a pH of <6.0 indicates groundwater is generally inadequate to maintain a stable pH in areas vulnerable to acidification. It is also noted that the alkalinity concentrations are approximately equal to the total acidity concentrations, indicating that some buffering capacity is present within the groundwater system to counterbalance some of the acidity.

Groundwater quality in the Leederville Aquifer is also considered to be acidic as evidenced by the high total acidity concentrations (up to 190mg$CaCO_3$/L) and pH generally <6.0. Alkalinity concentrations are in the low to moderate range indicating that groundwater is inadequate to maintain a stable, acceptable pH level. The alkalinity/sulfate ratio also indicates that groundwater is being affected by, or has already been affected by, the oxidation of sulfides.

8.4. POTENTIAL IMPACTS

Potential impacts from the Proposal on terrestrial environmental quality are:

- Leachate from untreated stockpiles and/or reburial of potential ASS material may enter groundwater, surface water and the Vasse-Wonnerup wetlands;
- Acidification of backfilled material (sand tails and clay fines), which may affect superficial groundwater quality, surface water quality (as run-off) and the Vasse-Wonnerup wetlands;
- Acidification of the process water circuit, which may be discharged to the environment and Vasse-Wonnerup wetlands;
- Reduction in groundwater as a result of dewatering potential ASS which may affect beneficial users of water such as livestock and non-potable uses.

8.5. ASSESSMENT OF IMPACTS

LEACHATE FROM UNTREATED STOCKPILES AND/OR REBURIAL OF POTENTIAL ASS

The risks associated with stockpiling potential ASS material may be high, even over the short term if stockpiles are untreated and left in oxidising conditions. Significant quantities of acid can be generated due to the exposure of sulfide minerals to oxygen, especially in coarsely textured, highly permeable, well sorted sandy stockpiles, which will dewater (drain) at a faster rate than fine-textured, poorly sorted soils. This acid build up will also generate metalliferous drainage/leachate which can readily infiltrate to groundwater,

runoff into surface water drains and potentially impact on sensitive environmental receptors such as the Lower Sabina River and the Vasse Wonnerup wetlands.

Strategic reburial involves the excavation of potential ASS and its placement in anoxic, preferably anaerobic (reducing) conditions at the base of a void, where sulfide oxidation and hence acid generation is permanently precluded (Dear, et al., 2014). Essential to the success of this technique is the strategic component. Soils to be reburied must have undergone zero or minimal oxidation, and their reburial location must be one that permanently precludes oxidation (i.e. below the permanent watertable). Strategic reburial therefore precludes actual ASS (i.e. soils which have already experienced oxidation). There may be risks to the environment (as described above) if the potential ASS is temporarily stockpiled above the water table before reburial. In addition, if the minimum watertable is not accurately determined, the reburied material will potentially be exposed to oxygen, acidify, release contaminants and may subside physically if water drains out of them (Dear, et al., 2014).

There is a limited potential for oxidation in soils with low hydraulic conductivities, such as blocky non-dispersive clays and clay rich soils, that are reburied under groundwater and compacted soil. However, there may be instances where dissolved oxygen concentration in water is high enough to cause oxidation of some submerged sediments (e.g. sulfidic fines). This risk increases when the oxygen transport mechanism is not limited to diffusion as moving water can transport oxygen much faster than diffusion can, and if the sediments are also resuspended then oxidation reactions may occur even faster. Fine-grained sulfidic sediments (such as clay fines from mineral sand processing), generally have much less favourable physical properties for strategic reburial and hence pose higher risks if reburied under water.

ACIDIFICATION OF PROCESSED MATERIAL

Processing of ore using hydraulic separation results in three streams of material, HMC, clay fines and sand tails. The three processed streams are then dealt with in the following manner:

- HMC is stockpiled and stored on-site until transport to Doral's Picton dry processing plant for further processing;
- Sand tails are hydraulically returned into pit voids (including as co-disposal);
- Clay fines are either hydraulically co-disposed with sand tails into pit voids or directed to SEPs to be consolidated for future disposal into mine voids.

During the hydraulic separation process, HMC and sand tails will be separated and generally 'washed' with the majority of reactive materials dissolving into the process water circuit (closed system). Sulfidic fines (e.g. pyrite) which have not yet dissolved in the process water circuit will be concentrated in the clay fines waste stream. This acidity present within the clay fines may then affect the quality of the rehabilitated soil profile if the sulfidic fines are exposed to oxygen (either during co-disposal or backfill of dried clay fines) and has the potential to affect groundwater via downward leachate.

SEP's containing clay fines have the potential for acidic water to migrate downwards into groundwater (if ponds are not self-sealing), reduce the quality of the process water pond due to acidic drainage being returned to the process water pond and also has the potential to impact surface water drainage features and potentially impact on sensitive environmental receptors such as the Lower Sabina River and the Vasse Wonnerup wetlands, should a breach of a SEP occur.

ACIDIFICATION OF THE PROCESS WATER CIRCUIT

Excavated ore that contains potential ASS will be processed through the wet concentration plant as soon as possible. As this material is maintained in the form of a wet slurry (i.e. saturated), the risk of sulfide oxidation is greatly reduced and as such will not require any active soil management if in this state. However as reactive materials dissolve into the process water circuit, the quality of water may become acidic and has the potential to mobilise metals. If not managed appropriately, acidic water can impact on groundwater quality (due to potential mounding under storage dams) and also surface water receptors (including the Lower Sabina River and Vasse-Wonnerup wetlands) if released during emergency discharge events.

REDUCTION IN GROUNDWATER QUALITY

Lowering of the water table (although passive) may potentially expose sulfide minerals to oxygen, resulting in some oxidation of *in situ* soils within the predicted dewatering drawdown extent. If the oxidation of *in situ* ASS generates sulfidic acidity then groundwater is the initial pathway by which impacts may migrate. Acidity could therefore be mobilised downwards by leachate, upwards with groundwater rebound, or laterally by groundwater migration. If acidic groundwater mobilises heavy metals they will migrate along the same pathways and have the potential to reduce the quality of bores screened within the Superficial Aquifer.

Although there are approximately 26 unlicenced bores screened within the Superficial Aquifer on-site, evidence suggests that many of these bores are disused or have been decommissioned. The remaining operational Superficial bores are used to abstract water from the Superficial Aquifer for predominantly livestock water and for domestic non-potable purposes (limited to one known bore), rather than drinking water purposes. Drinking water for residences in and around the Development Envelope is collected from rainwater tanks and/or abstracted from the Leederville Aquifer. All household bores use some degree of filtration circuit for iron and manganese. Leederville bores are unlikely to be affected by mining related drawdown and potentially reduced water quality.

8.6. MITIGATION

The key mitigation measure to reduce impacts to terrestrial environmental quality is to prepare and implement an ASSMP in consultation with DWER. The ASSMP (included as Appendix 3) includes specific treatment strategies designed to manage impacts to soil, groundwater and surface water receptors. A summary of the key management measures documented in the ASSMP is provided as follows:

- Mining activities will be scheduled to be undertaken on a campaign basis, with a portion of the ore body being mined and processed in a discrete time period to assist in minimising the area of groundwater drawdown at any one time;
- Topsoil/subsoil will be stripped to a depth of ~100mm, stockpiled for rehabilitation and neutralised if pH is <4.0pH;
- Overburden identified as ASS (i.e. NA > 0.03%S) will be reburied as soon as possible below the natural groundwater level into a mine void that is being actively backfilled with sand tails and/or clay fines resulting from ore processing. The sand tails and/or clay fines will be hydraulically returned over the overburden, maintaining the overburden material to anoxic conditions and providing additional buffering capacity, as a result of the addition of lime sand during the excavation and processing of ore;
- Excavated ore identified as ASS will be processed through the wet concentration plant as soon as possible. As this material is maintained in the form of a wet slurry (i.e. saturated), the risk of sulfide

oxidation is greatly reduced. The process slurry is maintained at pH5.5 to assist with the mineral separation process. As such, alkaline (lime sand) material will be added into the in-pit hopper during the excavation of ore to maintain pH5.5 and increase buffering capacity within the wet concentration process;

- Processing of ore results in three streams of material, HMC, clay fines and sand tails. These will be managed as follows:
    - HMC will be stockpiled and stored on a bunded alkaline pad. Leachate emanating from the stockpiled HMC will be captured and returned to the ore processing circuit, which is maintained at pH5.5;
    - Sand tails will be hydraulically returned to pit voids as a single waste stream and/or co-disposed with clay fines into pit voids. This material will have been maintained in a saturated state and with conditions maintained at pH5.5throughout the process. Furthermore, the unused (unreacted) lime sand that was added to the process at commencement of the ore processing sequence (i.e. at the in-pit hopper) will form part of this process stream, resulting in the addition of buffering capacity to the locations where this material is hydraulically returned. Sand tails will be regularly tested to ensure that the inherent acid neutralising capacity of this waste stream exceeds the acidity present. If necessary, additional lime sands will be incorporated during hydraulic disposal;
    - Clay fines will be managed by either:
        - Immediate co-disposal with sand tails by hydraulic return in existing mine voids; or
        - Directed to a SEP for storage and future use as void backfill.

      Clay fines that are immediately co-disposed with sand tails will be maintained in a saturated state prior to disposal and will include additional buffering capacity provided by the unused (unreacted) lime sands within the sand tails material. This material will be regularly tested to ensure that the acid neutralising capacity exceeds the acidity present in this waste stream.

      Clay fines material that are directed to the SEPs will also be regularly tested to ensure the acid neutralising capacity exceeds acidity of the waste stream. If insufficient buffering capacity is identified, additional neutralising material (lime sand) will be added prior to being discharged into a SEP. In addition to regular testing during discharge, this material will be re-tested following consolidation and drying within the SEP, prior to final disposal.
- Overburden and non-processed material identified as ASS, that will be used for site construction purposes (i.e. roads, pads, bunds etc) will either be:
    - Neutralised for re-use within 70 hours of excavation; or
    - Stockpiled on a treatment pad for up to 21 days prior to neutralisation and re-use.
- Water quality of the process water pond will be maintained by the addition of a suitable alkaline material to the in-pit hopper at the commencement of the ore processing sequence (where required) to ensure:
    - Field pH >5.5; or

  - TTA <40 mg$CaCO_3$/L; and
  - Total Alkalinity >30 mg$CaCO_3$/L.

- Preparation and implementation of plans and procedures relevant to the management of groundwater and surface water (including monitoring programs, trigger criteria, management responses and contingencies).

8.7. PREDICTED OUTCOME

Doral believes that with the implementation of the above mitigation measures (documented in the ASSMP) that the EPA's objective for terrestrial environmental quality 'to maintain the quality of land and soils so that environmental values are protected' can be achieved.

9. SOCIAL SURROUNDS

For social surroundings to be considered in EIA, there must be a clear link between the proposal or scheme's impact on the physical or biological surroundings and the subsequent impact on a person's aesthetic, cultural, economic or social surroundings.

Further, the above must also be read in context of 'significance' as defined in relation to significant proposals in subsection 37B(1) of the EP Act:

Significant proposal means a proposal likely, if implemented, to have a significant effect on the environment.

That is, for the EPA to consider social surroundings as a factor in EIA, a proposal's or scheme's effect on social surroundings, via its effect on the physical or biological environment, must be significant.

9.1. EPA OBJECTIVE

The EPA objective for Social Surroundings is:

To protect social surroundings from significant harm.

The objective recognises the importance of ensuring that social surroundings are not significantly affected as a result of implementation of a proposal or scheme.

9.2. POLICY AND GUIDANCE

Guidance relevant to terrestrial environmental quality that have been considered during the EIA process are documented in the following document:

- *Environmental Factor Guideline – Social Surroundings* (EPA, 2016h).

9.3. RECEIVING ENVIRONMENT AND POTENTIAL IMPACTS

ABORGINAL HERITAGE

Ethnosciences (2017) (Appendix 5) undertook a desktop Aboriginal Heritage survey of the Development Envelope to identify any known Aboriginal heritage issues that may affect the Proposal and to make recommendations for any further research and/or consultation that may be required to meet the requirements of the *Aboriginal Heritage Act 1972* (AH Act). The Development envelope is located wholly within the South West Boojarah #2 (WC06/4) native title claim, which is represented by the South West Aboriginal Land and Sea Council (SWALSC).

The desktop research involved the following:

- Examination of the Register of Aboriginal Sites using the online Aboriginal Heritage Inquiry System (AHIS) maintained by the Department of Planning, Lands and Heritage (DPLH);
- Review of previously published and unpublished ethnohistorical and ethnographic material, including previous heritage reports.

Results of the desktop research indicate that no Registered Aboriginal Sites or 'Other Heritage Places' are currently listed within or in close proximity to the Development Envelope.

A number of ethnographic sites surrounding the Development Envelope were identified including:

- Woddidup Mission/Mulgarnup Mission (DPLH 4401);

- Hithergreen Farm (DPLH 15999);
- Sabina River Camp Ground (DPLH 17350);
- Sabina River (DPLH 17353);
- Abba River (DPLH 17354);
- Uligugillup Mission (DPLH 17355);
- Hills Campsite (DPLH 18985);
- Vasse Highway Camp (DPLH 21571);

A number of archaeological sites surrounding the Development Envelope were also identified including:

- Sabina River Artefact Scatter (DPLH 16609);
- Tutunup Mine Artefact Cluster 01 (DPLH 19362);
- Tutunup South Modified Tree (DPLH 22883);
- Tutunup South Artefact Cluster (DPLH 22884);
- TUT 07-01 (DPLH 24568).

Ethnosciences (2017) also identified that although portions of the Development Envelope may have been subject to previous heritage surveys and broad-scale heritage investigations, no specific heritage surveys have been previously conducted over the entirety of the Development Envelope. There is, therefore, a possibility that currently unidentified enthnographic and archaeological sites may be present within the Development Envelope

Based on the desktop assessment (Ethnosciences, 2017) no impacts to Aboriginal Heritage are considered likely, should the Proposal be implemented. However, as recommended by Ethnosciences (2017) Doral will commission ethnographic and archaeological surveys of the Development Envelope, prior to carrying out any works that may impact an Aboriginal Site as defined by Section 5 of the AH Act.

NOISE

Environmental noise is regulated by the EP Act, through the implementation of the *Environmental Protection (Noise) Regulations 1997*.

It is proposed that the Proposal will operate on a continuous 24/7 roster. A noise assessment and corresponding noise management plan inclusive of noise mitigation and controls, shall be prepared for the Proposal and maintained throughout the construction and operational phases to ensure operation in accordance with the Noise Regulations. Due to the current stage of the Proposal, an assessment of predicted noise levels for noise sensitive premises (shown on Figure 9-1) as assigned by *Environmental Protection (Noise) Regulations 1997*, Part 2 Division 1 Regulation 8 (3) Table 1, has yet to be undertaken.

Figure 9-1 shows that there are presently 6 residences within the Development Envelope with a total of 15 residences within 2km of the proposed disturbance area.

Potential noise generating sources during construction and mining activities for the life of mine include:

- Fixed plant: feed hopper, mining unit, concentrator, tails booster pump, dewatering pumps and lighting tower (diesel powered);

- Mobile plant; bulldozer, grader, water cart, excavator, front end loader, trucks.

Noise levels will vary depending on the type of activities and prevailing wind conditions. During pre-mine establishment construction activities will be limited to day time only. Mining using fixed plant will be conducted continuously, and mobile machinery will be largely variable due to the demands of the operation at the time. Particular considerations will be given to operations during night time, Sunday and Public Holidays.

Dust

The Proposal will be located within rural farming land set on the Swan Coastal Plain ~11 km southeast of Busselton. Several farm houses are scattered around the local area within the vicinity of the mine site. The prevailing winds (for most of the year) in the southwest Region of Western Australia come from the east in the mornings and the south/southwest in the afternoons. In the winter months, strong westerly and north-westerly winds are prevalent.

Dry mining has the potential to generate dust from the stripping of topsoil and overburden, by vehicular movement and surface lift-off from exposed surfaces (e.g. stockpiles, mine pits) during dry and windy ambient conditions. Dust may also be generated from rehabilitation activities, and areas recently rehabilitated prior to the establishment of vegetation. Dust generation can result in adverse impacts on surrounding vegetation and create nuisance to landowners in the vicinity of the mine disturbance areas.

9.4. MITIGATION MEASURES

Noise

A Noise Management Plan will be prepared and implemented for the mine. The objective of the Noise Management Plan will be to maintain the amenity of neighbouring residences during mining operations. The Noise Management Plan will include noise management strategies and control measures to reduce noise emissions and as a minimum maintain compliance with the Noise Regulations. Noise management strategies will include, but not limited to the following:

- Select quietest equipment available and install silencers to reduce exhaust noise where possible;
- Ensure that no overburden fleet or ore fleet will operate simultaneously in the same mining block at any one time;
- Restrict the operation of machinery relative to worst case weather conditions on Sundays and Public holidays to minimise potential noise impacts;
- Restrict the operation of ancillary machinery (water cart and grader) to operate during day-time only;
- Establish preventative maintenance schedules for all vehicles, fixed plant and mobile equipment;
- Educate employees and contractors on the importance and requirements for noise management prior to commencing work on the mine, as part of the site induction process;
- Maintain ongoing effective dialogue with nearby residents to ensure noise impacts are communicated to Doral to allow for rapid resolution;
- Regular monitoring of noise emissions to measure performance of the noise control measures and ensure compliance;

- Continue to implement an effective public comment and complaint communication system to ensure all concerns are received, recorded and acted upon.

If noise limits are exceeded after the above management strategies are implemented, the following contingency actions will be implemented:

- Attenuation of machinery where practicable;
- Temporary shutdown of relevant (noise generating) operations to ensure compliance during persistent wind conditions;
- Investigate and implement methods to reduce noise emissions in accordance with best practice;
- Temporary relocation of the mining fleet to alternate mining pit to ensure compliance with respect to worst case scenario wind conditions.

Dust

Doral are experienced with dust management due to its previous experience at managing this issue at its Dardanup Mine.

It is expected air quality parameter limits will be included on the Proposal's *Environmental Protection Act 1986* Licence. Doral will regularly monitor TSP concentrations in accordance with the Dust Management Plan for the site. Doral will adhere to the limits set for dust within the licence, with a focus on minimising the concentration of TSP leaving the mine site and potentially impacting neighbours.

During the pre-mine establishment phase management may include employing up to three water carts for dust suppression on unsealed roads and in new areas of ground disturbance.

A range of control techniques will continue to be implemented to eliminate, minimise and control dust generation activities for the Proposal which include:

- Inform all employees and contractors of the importance of reducing the creation of dust generating activities;
- Restrictions on the areas open at any one time to ensure safe and efficient operations;
- Scheduling topsoil stripping as such to avoid periods of high winds;
- When necessary, stripping operations are to be suspended under particularly high wind conditions;
- Watering all high traffic and haulage areas on a routine basis for dust suppression ensuring that there is no runoff into vegetated areas. Up to three water carts will be available for use at any one time;
- Spreading stockpiles, noise control bunds and pond embankments with fine clay solution or PVA sealant such that dust control and soil erosion measures are achieved;
- Minimising the number and size of stockpiles. This involves the direct use of overburden as backfill and the direct replacement of topsoil, wherever possible;
- Encouraging vegetative cover on stockpiles, especially the topsoil stockpiles. Many of these vegetative species generate from stored seed to minimise dust generation;
- The management and monitoring of ore loading and unloading operations such that dust generation is minimised and controlled;

- Spraying HMC stockpiles at the mine with water if they dry to the extent dust generation occurs. HMC stockpiles generally have a moisture content of between 5-9% and are not vulnerable to the adverse effects of strong winds causing dust;
- The co-disposal of sand tails and clay tails into pit backfill areas. This homogenous mixing increases the average particle size and reduces the potential for dust generation;
- When and where necessary, spraying with water or other dust suppression measures (e.g. emulsion spray, erection of wind barriers) is employed;
- Employ routine maintenance and housekeeping practices to ensure that waste materials in and around the mine voids and infrastructure do not accumulate and lead to the generation on unacceptable airborne particulates.

9.5. PREDICTED OUTCOME

Doral are experienced at managing noise impacts associated with mineral sands mine sites. Noise levels associated with mining will be controlled as described above. Effective implementation of these noise management strategies will ensure noise emissions from the operations comply with the Noise Regulations.

Implementation of dust control measures will minimise dust generation. Monitoring of dust emissions will be conducted to ensure non-compliance with the Licence are acted upon.

Doral is confident that with the above measures in place, the EPA objective to protect social surroundings from significant harm can be achieved.

10. OTHER ENVIRONMENTAL FACTORS

Other environmental factors that Doral considers unlikely to be greatly impacted by the Proposal, and therefore not considered to be a significant environmental factor include:

- Terrestrial Fauna.

10.1. TERRESTRIAL FAUNA

For the purposes of EIA, the EPA defines Terrestrial Fauna as animals living on land or using the land (including aquatic systems) for all or part of their lives. Terrestrial fauna includes vertebrate (birds, mammals including bats, reptiles, amphibians and freshwater fish) and invertebrate (arachnids, crustaceans, insects, molluscs and worms) groups.

The EPA defines fauna habitat as the natural environment of an animal or assemblage of animals, including biotic and the abiotic elements, that provides a suitable place for them to live (e.g. breed, forage, roost or seek refuge).

10.1.1. EPA OBJECTIVE

The EPA objective for Terrestrial Fauna is:

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

10.1.2. POLICY AND GUIDANCE

Guidance relevant to Terrestrial Fauna that have been considered during the EIA process are documented in the following documents:

- *Environmental Factor Guideline – Terrestrial Fauna* (EPA, 2016g)*;*

10.1.3. RECEIVING ENVIRONMENT

SURVEYS COMPLETED

Harewood (2017) (Appendix 4) conducted a Level 1 Fauna Survey as defined by *EPA Guidance Statement 56 – Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia* (EPA, 2004b). As the general area is known to be utilised by Western Ringtail Possums (WRP) and Black Cockatoos, the scope of the survey work was expanded to include baseline assessment of the sites significance to these species. The fauna assessment (Harewood, 2017) therefore included:

- Level 1 Fauna Assessment;
- Targeted day and night searches for WRP habitat/site use (foraging, refuge and dispersal habitat and individuals);
- Preliminary Black Cockatoo habitat/site use assessment (opportunistic observations on potential habitat trees, foraging and roosting habitat);
- Identify and discuss any other potentially occurring significant fauna species and their habitat;
- Report summarising results, methods and conclusions.

FAUNA HABITATS

Approximately 95% of the Development Envelope has been totally cleared or almost totally cleared of native vegetation for livestock grazing, with only pasture grasses and the occasional widely spaced, scattered tree remaining. Parts of the Development Envelope have been planted with non-endemic/exotic tree species to act as wind breaks. Native remnant vegetation is mostly confined to road verges and along a small seasonally inundated tributary of the Lower Sabina River (Woddidup Creek). Most of this vegetation is dominated by woodlands containing various densities of marri, jarrah and/or flooded gum with or without midstorey species such as peppermint, paperbark or banksia. Almost all native vegetation present within the Development Envelope is in a Completely Degraded condition (Ecoedge, 2016).

Descriptions of the main fauna habitats/dominant vegetation present within the Development Envelope is provided in Table 10-1 (based on mapping by Ecoedge, 2016) and shown on Figure 10-1.

TABLE 10-1: FAUNA HABITAT TYPES

UNIT	BROAD FAUNA HABITAT TYPE	FAUNA HABITAT DESCRIPTION	AREA (HA)
A1	Woodland	Woodland of *Corymbia calophylla* and *Eucalyptus marginata*, with scattered *Agonis flexuosa*, *Banksia attenuata*, *B. grandis*, *Melaleuca preissiana*, *Nuytsia floribunda*, *Persoonia longifolia* or *Xylomelum occidentale* over *Xanthorrhoea preissii* over weeds on grey-brown or grey loamy sand or sand (on farmland usually only *C. calophylla* and *E. marginata* are present).	10.39
A2	Woodland	Woodland of *Corymbia calophylla* (sometimes with *Eucalyptus marginata* or *E. rudis*) with scattered *Melaleuca preissiana* or *Banksia littoralis* over open shrubland that may include *Acacia extensa*, *A. saligna*, *Hakea ceratophylla*, *H. lissocarpha*, *H. prostrata*, *H. varia*, *Kingia australis*, *Melaleuca viminea* and *Xanthorrhoea preissii* over weeds on seasonally wet grey loamy sand.	4.03
B1	Shrubland	Tall shrubland of *Acacia saligna*, *Banksia squarrosa* subsp. *argillacea*, *Calothamnus quadrifidus* subsp. *teretifolius*, *Hakea oldfieldii* and *Kunzea micrantha* (with scattered emergent *Eucalyptus rudis*) over scattered native herbs including *Drosera glanduligera* and *Sowerbaea laxiflora*, the sedge *Loxocarya magna*, and weeds on shallow red sandy clay on massive ironstone.	0.50
B2	Woodland	Woodland of *Eucalyptus rudis* and (in some areas) *Melaleuca rhaphiophylla* over weeds on massive ironstone.	2.93
C1	Woodland	Woodland of *Eucalyptus rudis* (and sometimes *Corymbia calophylla*) over scattered *Agonis flexuosa* and *Melaleuca rhaphiophylla* over weeds on grey-brown clayey loams in drainage lines.	17.97
C2	Open Shrubland	Open woodland of *Melaleuca preissiana* over weeds on seasonally wet brown clay-loam.	Not within Development Envelope

UNIT	BROAD FAUNA HABITAT TYPE	FAUNA HABITAT DESCRIPTION	AREA (HA)
C3	Open Shrubland	Tall Open Shrubland that may include *Acacia saligna*, *Jacksonia furcellata*, *Kingia australis*, *Melaleuca osullivanii*, *M. preissiana*, *M. viminea* and *Xanthorrhoea preissii* on seasonally wet grey-brown sandy loam.	0.55
D	Woodland	Woodland of *Agonis flexuosa* with scattered *Banksia attenuata* over weeds on grey sand on low dunes.	Not within Development Envelope
PL	Planted species	Planted non-endemic and exotic trees	4.92
CL	Cleared pasture	Existing cleared/highly degraded areas (e.g. paddocks/road verges) with scattered trees/shrubs. Some areas seasonally inundated/waterlogged	685.45
Not surveyed		Majority of non-surveyed areas are cleared farmland with some small areas of native vegetation	167.43
n/a	n/a	Seasonal creeks and drains (minor tributaries of the Sabina River)	-

Overall fauna habitat values within the Development Envelope have been severely compromised by the almost total removal (~95%) of native vegetation. Most areas lack any natural attributes and are now only likely to be utilised by generally common and widespread fauna species with non-specific requirements which allow them to persist in highly disturbed habitats. As a consequence, the fauna biodiversity of the Development Envelope is well below levels present prior to historical disturbance having occurred (Harewood, 2017).

Harewood (2017) notes however that the vegetation remaining within the Development Envelope still represents habitat for some species of conservation significance. Vegetation bordering the Lower Sabina River (~1km to the west of the Development Envelope) has also been identified as a regional ecological linkage axis line (Molloy, et al., 2009) which provides a corridor for wildlife movement (albeit tenuous) to areas either side of the Development Envelope.

VERTEBRATE FAUNA SPECIES

A total of 26 native fauna species were observed (or positively identified from foraging evidence, scats, tracks, skeletons or calls) within the Development Envelope during the day and night surveys (Harewood, 2017). Three introduced/domestic species were also recorded. Opportunistic fauna observations are listed in Appendix B of Harewood (2017).

A summary of potential vertebrate fauna species potentially occurring within or utilising at times the Development Envelope, based on results from the literature review and observations made during the field assessment are provided in Table 10-2. A complete list of vertebrate fauna possibly inhabiting or frequenting the Development Envelope is provided in Appendix B of Harewood (2017).

TABLE 10-2 SUMMARY OF POTENTIAL VERTEBRATE SPECIES

GROUP	TOTAL NO. OF POTENTIAL SPECIES	POTENTIAL NO. OF SPECIALLY PROTECTED SPECIES	POTENTIAL NO. OF MIGRATORY SPECIES	POTENTIAL NO. OF PRIORITY SPECIES	NO. OF SPECIES RECORDED DURING FIELD ASSESSMENT
Amphibians	8	0	0	0	1
Reptiles	13	0	0	0	0
Birds	78[1]	4	2	0	23
Non-Valent mammals	11[8]	1	0	0	5[3]
Volant Mammals (Bats)	8	0	0	0	0
TOTAL	**118[9]**	**5**	**2**	**0**	**23[3]**

Subscript = no. of introduced species included in total

CONSERVATION SIGNIFCANT FAUNA SPECIES

A review of the EPBC Act threatened fauna list, DBCA's threatened fauna database and priority list, unpublished reports and scientific publications by Harewood (2017) identified a number of specially protected, priority or migratory vertebrate fauna species as potentially occurring in the general vicinity of the Development Envelope. Harewood (2017) notes that of these species, most have no potential whatsoever to utilise the Development envelopment for any purpose and have been omitted from the potential list (Appendix B of Harewood, 2017), principally due to lack of suitable habitat (including extent and/or quality) or known local extinction.

One vertebrate fauna species of conservation significance however was positively identified as utilising the Development Envelopment for some purpose during the Harewood (2017) survey. This species is:

- Western Ringtail Possum *Pseudocheirus occidentalis* - S1 (*WC Act*), Vulnerable (*EPBC Act*).

Five individuals were recorded along McGibbon Track during the night survey. Also potentially present in other sections of the Development Envelope which were not examined.

Based on the habitats present and current documented distributions it is considered possible that the following additional species of conservation significance may use the Development Envelope for some purpose at times, though, as no evidence of any using the Development Envelope at the time of the field survey was found, the status of some in the area remains uncertain.

These species are:

- Eastern Great Egret *Ardea alba (modesta)* – S5 (*WC Act*), Migratory (EPBC Act). This species potentially utilises creek lines, drains and paddocks when inundated during the wetter months of the year in small numbers. Unlikely to breed onsite;
- Peregrine Falcon *Falco peregrinus* – S7 (*WC Act*). This species potentially utilises some sections of the Development Envelope as part of a much larger home range. No evidence of nesting seen and

the probability of this species breeding within the Development Envelope can be considered to be very low;

- Rainbow Bee-eater *Merops ornatus* – S5 (*WC Act*), Migratory (*EPBC Act*). This species is a common seasonal visitor to south west. Possibly breeds in some sections of the Development Envelope where ground conditions permit (e.g. sandy areas) though population levels would not be significant as it usually breeds in pairs, rarely in small colonies (Johnstone & Storr, 1998);
- Carnaby`s Black-Cockatoo *Calyptorhynchus latirostris* – S2 (*WC Act*), Endangered (*EPBC Act*). Not observed during the survey period but known to frequent the general area. Small areas of favoured foraging habitat (i.e. marri, jarrah and banksia) present. Larger trees (>50cm DBH) can be considered potential breeding habitat. No roosting sites identified within the Development Envelope;
- Forest Red-tailed Black-Cockatoo *Calyptorhynchus banksii naso* – S3 (*WC Act*), Vulnerable (*EPBC Act*). Not observed during the survey period but known to frequent the general area. Small areas of favoured foraging habitat (i.e. marri, jarrah and banksia) present. Larger trees (>50cm DBH) can be considered potential breeding habitat. No roosting sites identified within the Development Envelope;
- Baudin's Black-Cockatoo *Calyptorhynchus baudinii* – S2 (*WC Act*), Vulnerable (*EPBC Act*). Not observed during the survey period but known to frequent the general area. Small areas of favoured foraging habitat (i.e. marri and banksia) present. Larger trees (>50cm DBH) can be considered potential breeding habitat. No roosting sites identified within the Development Envelope.

As indicated for some species, habitat within the Development Envelope, while considered possibly suitable, may be marginal in extent/quality and species listed may only visit the area for short periods, or as rare/uncommon vagrants/transients. Harewood (2017) notes that due to the relatively small extent of natural fauna habitat within the Development Envelope and the remnants present are generally highly degraded and fragmented, the overall value to fauna can be regarded as low when compared to other nearby areas such as the Whicher range and Ludlow Tuart Forest.

A number of other species of conservation significance, while possibly present in the wider area (e.g. Whicher Range), are not listed as potential species due to known localised extinction (and no subsequent recruitment from adjoining areas), lack of suitable habitat and/or the presence of feral predators.

10.1.4. POTENTIAL IMPACTS

The Proposal may result in the following impacts to fauna and fauna habitats:

- Vegetation clearing for the Proposal will directly remove up to ~1.67ha of fauna habitat which may be used for foraging, breeding, roosting or dispersal;
- Impacts to fauna of conservation significance and their habitats;
- Dewatering activities may affect GDE's and affect the value of fauna habitat;
- Increase in the number of predatory introduced species;
- Light and noise emissions could disrupt fauna behaviour;
- Vehicle movements during construction and operation may result in the loss of individual fauna, especially less-mobile species, from vehicle strikes.

10.1.5. ASSESSMENT OF IMPACTS

VEGETATION CLEARING

Almost all native fauna rely on native vegetation to provide food, shelter and breeding sites. Clearing of native vegetation may reduce the capacity of the habitat to support fauna potentially resulting in the displacement of fauna.

Results of the fauna survey suggest that up to 109 native fauna species have the potential or are likely to utilise the Development Envelopment for some purpose at times. Twenty six (~24%) of the predicted native species were observed within the Development Envelope during the various daytime and night time surveys. Disturbance for the Proposal will primarily be confined to cleared paddock areas and therefore the clearing required will only involve the removal of a very small area of native vegetation, predominantly as isolated paddock trees and/or overstory species (woodland species). These areas would only be utilised by a very small percentage of the predicted/known species given their very low habitat values and do not therefore comprise areas of high biological diversity. Furthermore, the extent of natural fauna habitat within the Development Envelope is relatively small and the remnants present are generally highly degraded and fragmented (Harewood, 2017).

Therefore, given that the existing value of habitat to fauna is low, along with anticipated location and probable extent of the Proposal, clearing of ~1.67ha of native vegetation (as woodland habitat) is extremely unlikely to affect any area of habitat considered to be of high biological diversity.

Molloy *et al.,* (2009) identified a regional ecological link axis line passing within 1km to the west of the Development Envelope. As the disturbance area for the Proposal will not dissect any significant ecological corridor, fragmentation of fauna habitat is unlikely to occur.

IMPACTS TO FAUNA OF CONSERVATION SIGNIFICANCE

The potential impacts to fauna of conservation significance and their habitats known to occur or considered possibly to occur within the Development Envelope (as identified in Section 10.1.3) are outlined in Table 10-3.

TABLE 10-3 POTENTIAL IMPACT ON CONSERVATION SIGNIFCANT FAUNA KNOWN OR POSSIBLY OCCURING WITHIN THE DEVELOPMENT ENVELOPE

SPECIES	HABITAT PRESENT (YES/NO)	LIKLIHOOD OF OCCURENCE	POSSIBLE IMPACT/ SIGNIFCANCE OF POSSIBLE IMPACT
Mammals			
Western Ringtail Possum *Pseudocheirus occidentalis*	Yes	Known to occur	No impact/Negligible. Harweood (2017) notes that based on available information, any clearing for the Proposal will be limited to a small number of paddock trees in paddock areas. This vegetation does not represent WRP habitat and therefore none of the DoEE criteria listed in *Significant Impact Guidelines for the vulnerable Western Ringtail Possum (Pseudocheirus occidentalis) in the southern Swan*

SPECIES	HABITAT PRESENT (YES/NO)	LIKLIHOOD OF OCCURENCE	POSSIBLE IMPACT/ SIGNIFCANCE OF POSSIBLE IMPACT
			Coastal Plain, Western Australia (DEWHA, 2009) will be compromised.
Birds			
Black Cockatoos Given the similar habitat requirements the following species have been considered together: • The Forest Red-tailed Black-Cockatoo (*Calyptorhynchus banksii naso*); • Baudin's Black-Cockatoo (*Calyptorhynchus baudinii*); and • Carnaby`s Black-Cockatoo (*Calyptorhynchus latirostris*).	Yes	Possibly occurs	Loss of very small number of isolated trees/negligible. Harewood (2017) notes that based on available information, it is considered unlikely that the Proposal will comprise any of the criteria listed in the DoEE document *EPBC Act referral guidelines for three threatened black cockatoo species* (DSEWPaC, 2012).
Peregrine Falcon *Falco peregrinus*	Yes	Possibly occurs but only rarely.	No impact/Negligible.
Rainbow Bee-eater *Merops ornatus*	Yes	Possibly occurs	No impact/Negligible. No significant impact on this species is anticipated as individuals' present at any one time are unlikely to represent a substantial proportion of the population. It can be expected to continue to utilise the area, if it does now, despite the Proposal going ahead.
Eastern Great Egret *Ardea alba (modesta)*	Yes	Possibly occurs	Temporary loss/modification of highly degraded areas of foraging habitat/Negligible.

DEWATERING ACTIVITIES

Dewatering of potential GDE's has the potential to reduce the quality of fauna habitat within the Development Envelope. However, given the current extent of natural fauna habitat within the Development Envelope is relatively small and the remnants present are generally highly degraded and fragmented, the overall value to fauna is regarded as low when compared to other nearby areas such as the Whicher Range and Ludlow Tuart Forest ((Harewood, 2017).

Potential impacts to GDE's from dewatering (although preliminary at this stage) are discussed in Section 5.5 and 6.5.

INCREASED PREDATION

Some fauna species (particularly smaller mammals) are sensitive to predation by foxes and feral cats. Foxes and feral cats may increase in abundance around the proposed minesite from an increase in the abundance of rodents, access to waste/scraps and/or from feeding by personnel. Waste management procedures will be implemented by Doral to ensure that fauna have no access to scraps or rubbish.

LIGHT AND NOISE EMISSIONS

Light and noise emissions are all likely to increase as a result of mining activities. The impacts of these emissions on fauna are difficult to predict and therefore a precautionary approach will be adopted and emissions will be reduced as far as practicable. A Noise Management Plan will be developed and implemented to minimise noise emissions and impacts. Lighting will be directed onto construction and operational areas and will be in accordance with Australian Standard *AS4282-1997 Control of the obtrusive effects of outdoor lighting*.

INCREASE IN VEHICLE MOVEMENTS

Clearing of native vegetation and/or isolated paddock trees by machinery prior to mining is likely to result in an impact on resident fauna, particularly on less mobile species. The construction and operation of the Proposal will result in an increase in vehicle movement to and from the site. Vehicle movements may result in the loss of individual fauna, especially less-mobile species, from vehicle strikes.

Some loss of fauna may occur as a result of these activities, however mitigation measures will be implemented to ensure that impacts to fauna are minimised. Isolated deaths of individual fauna are not expected to affect the distribution or conservation status of any fauna species.

Mitigation measures will include:

- Pre-clearing Surveys;
- Restricted speed limits on access roads;
- Education of contractors during inductions and regular toolbox meetings.

10.1.6. MITIGATION

Doral will develop and implement a Fauna Management Plan to address potential impacts to fauna of conservation significance and their associated habitat. The Fauna Management Plan will include the following key management actions:

- Development and implementation of specific clearing procedures to minimise impacts to fauna and fauna habitats. This will include demarcation of cleared areas, pre-clearing surveys and authorisation requirements;
- Where possible (if habitat trees are identified), clearing activities will be conducted within the months of January and February to avoid the documented breeding season of fauna of conservation significance, particularly Black-Cockatoos. If clearing is required outside of this preferred timeframe, any trees with potential nest hollows will be inspected for any evidence of nesting activity. If any are found to be in use, clearing in this area will be postponed until such a time that the tree is vacated.

- A suitably qualified fauna spotter/carer will be on site during clearing operations to conduct daily checks of vegetation to be cleared and retrieve fauna if necessary. The fauna spotter will be responsible for all activities related to the protection and welfare of individual fauna;
- Vehicle speeds on site will be restricted. All collisions with fauna are to be reported and recorded through Doral's Hazard and Incident Management System (DHIMS);
- Native fauna injured during clearing or normal site operations should be taken to a designated veterinary clinic or a nominated wildlife carer;
- No dead, standing or fallen timber will be removed from site unnecessarily. Logs and other debris resulting from land clearing will be used to enhance fauna habitat in untouched and rehabilitated areas;
- All staff working on site will be educated with regards to protected fauna;
- Weapons and pets will not be permitted on site;
- Wastes will be managed appropriately to ensure that fauna have no access to scraps or rubbish
- Contribute to feral species removal such as fox/cat;
- Lights at night will be directed towards construction and operation activities and will be in accordance with *AS4282-1997 Control of the obtrusive effects of outdoor lighting.*

Environmental targets and performance indicators will be developed to ensure fauna management can be monitored and audited.

10.1.7. PREDICTED OUTCOME

Based on available information, no substantial impacts on any fauna species or overall biodiversity values are anticipated as a consequence of implementing the Proposal. In cases where some impacts are anticipated, the degree of the impact is only expected to be very low and relates to the loss of very small areas of habitat, primarily in the form of a small number of scattered, isolated paddock trees and/or overstory species. This coupled with the fact that most of the species known to or likely to occur are common and widespread, no overall change in their conservation status is anticipated, despite a possible, very localised/small reduction in habitat extent.

At the Commonwealth level, an assessment using published DoEE criteria suggests that "significant impact "is not likely to any of the four species of listed EPBC Act species known to or likely to utilise the area, primarily given the small area of degraded vegetation likely to be affected.

Doral considers that with the implementation of the above listed key mitigation measures (via the Fauna Management Plan), the EPA's objective to maintain representation, diversity, viability and ecological function at the species, population and community level can be achieved.

11. REFERENCES

Ahern, C., McElnea, A. & Sullivan, L., 2004. *Acid Sulfate Soils Laboratory Methods Guidelines. ,* Indooroopilly, Queensland, Australia.: Queensland Department of Natural Resources, Mines and Energy.

Australian Government, 2013. *Interim Biogeographic Regionalisation of Australia (IBRA) Version 7, Department of the Environment, Water, Heritage and the Arts. Retrieved August 2017.http://www.environment.gov.au/topics/land/national-reserve-system/science-maps-and-data/australias-bior*.

Baddock, L., Vine, J. & Leathersich, M., 2005. *South West Yarragadee Hydrogeological Investigations and Evaluation, Southern Perth Basin. Infrastructure Planning Branch.*Water Corporation.

Canham, C., Froend, R. & Stock, W., 2009. Water stress vulnerability of four Bansksia species in contrasting ecohydrological habitats on the Gnangara Mound, Western Australia. *Plant Cell Environ,* 32(1), pp. 64-72.

DAF, 2014. *Declared plants. https://www.agric.wa.gov.au/pests-weeds-diseases/weeds/declared-plants.*

Davidson, 1995. *Hydrogeology and Groundwater Resources of the Perth Region.* Geol. Soc. WA Bulletin 142.

Dear, S. et al., 2014. *Queensland Acid Sulfate Soil Technical Manual: Soil Management Guidelines. ,* Queensland Government.: Brisbane: Department of Science, Information Technology, Inovation and the Arts.

DEC, 2008. *Geomorphic Wetlands of the Swan Coastal Plain GIS Mapping dataset. Department of Environment and Conservation. Perth, Western Australia.*

DEC, 2010. *Definitions, categories and criteria for threatened and priority ecological communities. Department of Environment and Conservation, Perth, Western Australia.*

Del Borello, 2008. *Management triggers and responses for groundwater-dependent ecosystems in the South West groundwater Areas. Water resource allocation planning series Report 31, Department of Water, Western Australia.*

Department of Environment, 2007. *Ecological Character description, Vasse-Wonnerup RAMSAR wetlands site in south-west western Australia.*

DER, 2014. *Assessment and Management of Contaminated Sites.* Government of Western Australia.

DER, 2015a. *Identification and Investigation of Acid Sulfate Soils and Acidic Landscapes*.

DER, 2015b. *Treatment and Management of Soil and Water in Acid Sulfate Soil Landscapes*.

DEWHA, 2009. *Significant impact guidelines for the vulnerable western ringtail possum (Pseudocheirus occidentalis) in the southern swan Coastal Plain, Western Australia.*Australian Government.

Doral, 2017. *Acid Sulfate Soil Investigation and Management Plan - Yalyalup Mineral Sands Deposit, Yalyalup WA.*

DoW, 2009b. *A draft water quality improvement plan for the Vasse Wonnerup Wetlands and Geographe Bay,* s.l.: Department of Water.

DoW, 2009. *Whicher Area Surface Water Allocation Plan. Water resource and planning series Report 19. Department of Water, Western Australia*.

DoW, 2010. *Vasse-Wonnerup Wetlands and Geographe Bay Water Quality improvement Plan.* Government of Western Australia.

DSEWPaC, 2012. *EPBC Act Referral guidelines for three threatened black cockatoo species: Carnaby's cockatoo (endangered) Calyptorhynchus latirostris, Baudin's cockatoo (vulnerable) Calyptorhynchus baudinii, Forest red-tailed black cockatoo (vulnerable) Calyptorhynchus b,* s.l.: Australian Government.

Ecoedge, 2016. *Report of a Level 1 Flora and Vegetation Survey at the Yalyalup Proposed Mine Area.*

Environment Australia, 2001. *National objectives and targets for biodiversity conservation 2001-2005.* s.l.:hhtp://www.environment.gov.au/resource/national-objectives-and-targets-biodiversity-conservation-2001%E2%80%932005.

EPA, 2000. *Environmental Protection of Native Vegetation in Western Australia. EPA Position Statement No. 2. EPA, Perth.*

EPA, 2004a. *EPA Guidance Statement 51 - Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia,* Perth, WA.

EPA, 2004b. *EPA Guidance Statement 56 - Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia.,* Perth, WA.

EPA, 2006. *Level of Assessment for Proposals affecting Natural Area within the System 6 Region and Swan Coastal Plain Portion of the System 1 Region. Guidance Statement No. 10. June 2006, Perth.*

EPA, 2016a. *Environmental impact Assessment (Part IV Divisions 1 and 2) Procedures Manual.* Perth WA.

EPA, 2016b. *Environmental Factor Guideline - Flora and Vegetation.* Perth, WA.

EPA, 2016c. *Technical Guidance - Flora and Vegetation Surveys for Environmental Impact Assessment.* Perth WA.

EPA, 2016d. Environmental Factor Guideline - Hydrological Processes.

EPA, 2016e. Environmental Factor Guideline - Inland Waters Environmental Quality.

EPA, 2016f. Environmental Factor Guidline - Terrestrial Environmental Quality.

EPA, 2016g. *Environmental Factor Guideline - Terrestrial Fauna*.

EPA, 2016h. *Environmental Factor Guideline - Social Surroundings*.

Ethnosciences, 2017. *Report of a Desktop Aboriginal Heritage Assessment of Doral's Yalyalup Project Area near Busselton, Western Australia*.

Gibson, N., Keighery, G. & Keighery, B., 2000. Threatened plant Communities of Western Australia. 1 The Ironstone Communities of the Swan and Scott Coastal Plains. *Journal of the Royal Society of Western Australia,* Volume 83, pp. 1-11.

Harewood, 2017. *Fauna Assessment - Yalyalup Project Area. August 2017 V1*.

Hirschberg, 1989. *Busselton shallow-drilling groundwater investigation: Western Australia Geological Survey, Professional Papers, Report 25, p. 17-37*.

HydroSolutions, 2017. *Initial Hydrogeological Assessment: Proposed Yalyalup Mineral Sands Mine.* Unpublished report prepared for Doral Mineral Sands Pty Ltd.

Johnstone, R. & Storr, G., 1998. *Handbook of Western Australian Birds: Volume 1 - Non-passerines (Emu to Dollarbird). ,* s.l.: Western Australian Museum, Perth, Western Australia..

Keighery, 1994. *Bushland Plant Survey: A guide to plant community survey for the community..* s.l.:Wildlife Society of Western Australia (Inc.), Nedlands, Western Australia.

Lindenmayer, D., 2001. *On borrowed time: Australia's environmental crisis and what we must do about it..* s.l.:Penquin/CSIRO Publishing, Camberwell, Victoria..

Mattiske, E. M. & Havel, J. J., 1998. Vegetation Complexes of the South-West Forest Region of Western Australia. Maps and report prepared as part of the Regional Forest Agreement. Western Australia for the Department of Conservation and Land Management and Environment Australia..

Meissner, R. & English, V., 2005. *VShrubland Association on Souther Swan Coastal Plan Iron stone (Busslton area) (Souther Ironston Association) Interim recovery plan no. 215,* s.l.: Department of Environment and Conservation, Species and Communties Branch.

Molloy, S. et al., 2009. *South West Regional Ecological Linkages Technical Report, Western Australia.,* s.l.: Local Government Association and Department of Environment and Conservation Perth..

Pettit, N., Ladd, P. & Froend, R., 1998. Passive clearing of native vegetation: Livestock damage to remnant jarrah (Eucalytus marginata) woodlands in Western Australia. *Journal of the Royal Society of Western Australia,* Volume 81, pp. 95-106.

Schafer, D., Johnson, S. & Kern, A., 2008. *Hydrogeology of the leederville aquifer in the western Busselton-Capel Groundwater Area. Hydrogeological record series Report HG31.,* s.l.: Department of Water.

Tille, P. & Lantzke, N., 1990. *Busselton Margaret River Augusta Land Capability Study. Land resources Series No. 5. Department of Agriculture..* Perth, WA.: s.n.

Varma, 2009. *Southern Perth basin groundwater-resource assessment: Application of the SWAMS and ESCP models, Department of Water, Government of Western Australia, Hydrogeological record series, Report no. HG26..* s.l.:s.n.

Water Corporation, 2005. *South West Yarragadee Hydrogeological Investigations and Evaluation, Southern perth Basin. Infrastructure Planning Branch, Planning and Development Division..* s.l.:s.n.

Webb, 2004. *The Busselton Ironstone Shrubland Threatened Community. Presentation to the Busselton Ironstones Threatened Ecological Community Workshop. geographe Bayview Resort, Busselton, 23-24 November 2004..* s.l.:s.n.

Webb, A., Keighery, B., Keighery, G. & Longman, V., 2009. *The flora and vegetation of the Busselton Plain (Swan Coastal Plain): a report for the Department of Environment and Conservation as part of the Swan Bioplan Project.,* Perth, Western Australia.: Department of Environment and Conservation..

Webb, A., Kinloch, J., Keighery, G. & Pitt, G., 2016. The extension of vegetation complex mapping to landform boundaries within the Swan Coastal Plan landform and forested region of south west Western Australia.

Williams, K., Horan, S. & Webb, A., 2001. *Declared Rare and Poorly Known Flora in the Central Forest Region,* s.l.: Department of Conservation and Land Management, State Species Management Plan.