



Cristal Mining Australia Limited
Cable Sands (W.A.) Pty Ltd

**Mining Proposal
for the
Wonnerup South Mineral Sands
Deposit
M70/785
Yalyalup Western Australia**

16 October 2013

Cristal Mining Australia Limited
ABN 60 009 247 858
Koombana Drive, Bunbury WA 6230, Australia
PO Box 133, Bunbury WA 6231, Australia
T 61.8.9721.0200 F 61.8.9721.1249
www.cristalmining.com

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Purpose

This Mining Proposal for the Wonnerup South Project (M70/785) has been prepared to address the requirements of the Department of Mines and Petroleum (DMP) guidelines (2006). The Mining Proposal provides detailed information on the investigation, evaluation and proposed management of potential significant environmental impacts relevant to the proposed operations and the surrounding environment.

The Mining Proposal also describes the list of further environmental approvals that will be required under other relevant legislation, including but not limited to:

- referral of a likely controlled action, managed by the (Commonwealth) Department of Sustainability, Environment, Water, Population and Communities (DSEWPAC)
- a native vegetation clearing permit, managed by the DMP
- a groundwater dewatering permit, managed by the Department of Water (DoW)
- a works approval and operating licence, managed by the Department of Environmental Regulation (DER)
- a Section 18 application to use land under the *Aboriginal Heritage Act 1972*, managed by the Department of Aboriginal Affairs (DAA).

The Mining Proposal is supported by a Mine Closure Plan for the Wonnerup South Project.

Mining Proposal Checklist

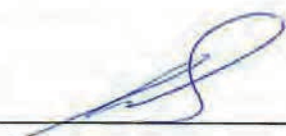
Q#	Checklist	Y/N /NA	Reference	Comments
1	Are you aware that this mining proposal is publicly available?	YES		
2	Is there any information in this mining proposal that should not be publicly available?	NO		
3	If "No" to Q2, do you have any problem with the information contained in this mining proposal being publicly available?	NO		
4	If "Yes" to Q2, has confidential information been submitted in a separate document/section?	NA		
5	Has the mining proposal been endorsed? See last page Checklist.	YES		SIGNED
6	Have you included the tenement number(s), site name, proposal overview and date in the title page?	YES		
7	Who authored the mining proposal? (Please include telephone number of author)		Neil Dixon Ennovate Environmental Consulting on behalf of Cristal Mining Australia Ltd Tel: 0407 263 635	
8	State who to contact enquiries about the mining proposal		Neil Dixon email: ndixon@cristal.com	
9	How many copies were submitted to DMP?		Hard copies Electronic copies	None EARS
10	Does this mining proposal support a lease application?	NO		M70/785 granted
11	Has a geological resource statement been included (refer section 4.3.2 of mining proposal guidelines)?	YES	S 3.4	
12	Will more than 10 million tonnes of ore and waste be extracted per year? State total tonnage:	NO	Page vi	3.3 Mt of ore in total
13	Will more than two million tonnes of ore be processed be year? State total throughput.	YES	Page vi	Throughput 2.5 Mtpa
14	Is the mining proposal located on pre-1899 Crown Grant lands? (not subject to the Mining Act)	NO	Page 1	
15	Is the mining proposal located on reserve land? If "Yes" state reserve types	NO	Page 2	
16	Will the mining proposal occur within or affect a declared occupied townsite?	NO	Page 2	Wonnerup townsite is closest at 2.3 km
17	Is the mining proposal within two km of the coastline or a Private Conservation Reserve?	NO	Figure 1	
18	Is the mining proposal wholly or partially within a World Heritage Property, Biosphere Reserve, Heritage Site or Soil Reference Site?	NO	Figure 1	
19	Are all mining operations within granted or applied for tenement boundaries?	YES	Figure 2	M70/785
20	Are you the tenement holder of all tenements?	YES		

Q#	Checklist	Y/N /NA	Reference	Comments
21	If "No" at 20, do you have written authorisation from the tenement holder (s) to undertake the Mining proposal activities (Refer to section 4.2.1 of the Mining Proposal Guidelines)	NA		
22	Is "Yes" at 21, is a copy of the authorisation contained within the mining proposal?	NA		
23	Have you checked for compliance against tenement conditions?	YES	P 48	No non compliance or inconsistencies
24	Have you included location plans showing tenement boundaries and mining operations?	YES	Figure 2	
25	Have you included site layout plans showing all mining operations and infrastructure in relation to tenement boundaries?	YES	Figure 2	
26	Have you included Area of Disturbance Tables for all tenements impacted by mining operations?	YES	Table 8	
27	Does the mining proposal require referral under part four or the MOU? If 'Yes' describe why in space below:	NO		Criteria in MOU not triggered but Proponent is referring to EPA regardless. Neighbouring Wonnerup mine referred to EPA in 2010 and 'Not Assessed'.
28	Has the EPA set a level of assessment? If yes state:	NA		
29	Is a clearing permit required? If 'No' then explain why in space below?	YES		
30	If 'Yes' at Q29 then has a permit been applied for?	NO		In process
31	Is a works approval required by the DEC?	YES		
32	Has a Works Approval been submitted to the DEC?	NO		In process
33	Stakeholder Consultation - Have the following stakeholders been consulted? (use NA if not relevant) <ul style="list-style-type: none"> • City of Busselton • Pastoralist • DER • Main Roads • DOW • DSEWPAC 	YES YES YES YES YES YES	28	Table 5 Agreement appended in Attachment 1 As part of Wonnerup Mine consultation Dewatering EPBC referral
34	Is the mining proposal wholly or partially within DEC managed areas?	NO		
35	If 'yes' at Q34 has DEC been consulted?	NA		

Q#	Checklist	Y/N /NA	Reference	Comments
36	Is the mining proposal wholly or partially within a red book area or a bush forever site?	NO		
37	Will the mining proposal impact upon a water resource area, water reserve, declared or proposed catchment, groundwater protection area, significant lake or wetland?	NO		
38	Is a water or de-watering licence required?	YES		
39	If 'Yes' at Q38 then has the licence(s) been applied for?	NO		In process
40	Does the mining proposal include new tailings storage or changes to existing tailings storage?	YES		Temporary (2-3 yrs) fines drying dams are proposed; constructed and operated in accordance with an existing Management Plan
41	Has ASS assessment been undertaken?	YES	Page 13	Section 3.3
42	Have flora and fauna checks been undertaken?	YES	S 3.8-9	Section 3.5, 3.6
43	Are any rare species present?	YES	S3.9	Baudin's Black Cockatoo and Western Ringtail Possum
44	Has preliminary closure plan been included?	YES	S 7	Section 7
45	Do you acknowledge that the hard copies and the CD contain identical information? (this is important for DMP's electronic records system)	YES		Mining Proposal lodged on EARS. Hard copy and attachments provided by mail

I hereby certify that to the best of my knowledge the above checklist accurately reflects the information contained within this Mining Proposal.

Name: KEN BELL Position: OPERATIONS MANAGER

Signed:  Date: 16-10-13

Summary of the Proposal

The Cristal Mining Australia Ltd (Cristal) Wonnerup South Mineral Sands Project (the Proposal) comprises the development of the Wonnerup South heavy mineral sand deposit (M70/785) and is an extension of Cristal's Wonnerup mine.

The Proposal will extract 3.5 million tonnes (Mt) of ore from the Wonnerup South reserve and pump it 700 m to the Wonnerup wet separation plant to produce approximately 200,000 t of heavy mineral concentrate (HMC) for transport to Cristal's Mineral Separation Plant (MSP) at Bunbury for further processing.

The Proposal will directly disturb no more than 190 ha out of a tenement area of 411 ha, the majority of which is cleared farmland. The Proposal is located on a single freehold title (Lot 3819 on Plan 153196) and will be developed under an agreement with the landowners (see Attachment 1).

The timing for the development, operation and closure of the Proposal is, in part, driven by ambitions of the City of Busselton to expand the adjacent Busselton Regional Airport (BRA), which would otherwise sterilise a sizeable portion of the Wonnerup South deposit. To avoid this outcome, City of Busselton has been working closely with Cristal so that both parties can time their activities accordingly.

Initial development of the Proposal is expected to commence in early 2016, once all necessary environmental and other access and operating approvals have been secured. Ore recovery for mineral production will commence in 2017 and continue for a period of approximately 20 months. During this period, mining for ore at Wonnerup will pause as the earthmoving and primary screening equipment and personnel are relocated across to the Proposal site. Recovered ore will be screened on site and pumped as a slurry across to the wet concentrator in operation at the Wonnerup mine and tailings will be returned to the Proposal site and backfilled into the finished mining areas.

The environmental assessments and management of the Proposal will build upon the investigations, approvals and management systems developed for the adjacent Wonnerup mine. Cristal has consulted with the Department of Environment and Regulation (DER), the Department of Water (DoW) and the Commonwealth Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC) in regards to the proposed mining project and has developed a good understanding of the expectations of each assessing agency.

Environmental, social and land-use aspects of relevance to the Proposal are:

- proximity of Sabina River (a registered Aboriginal Site), which is connected to the Vasse Wonnerup system (a Ramsar wetland)
- proximity of housing estates (1.5 km)
- clearing of native trees (up to 90 individual paddock trees and five small remnants of less than 1 ha each)
- localised potential acid sulfate soils and dewatering of deeper sections of the pit
- forthcoming expansion of the Busselton Regional Airport and construction of the Busselton Outer Bypass road, which involve land within the mining tenement, including resource areas.

Cristal has previously established a register of residences within 2 km of the neighbouring Wonnerup mine, for which extensive community consultation was undertaken, including public advertising and input to the various approvals required for the mine. This register has been expanded to include the residences within 2 km of the Proposal and a neighbourhood and community consultation program has been developed.

Consultation on Aboriginal heritage matters has involved representatives of the South West Boorarah and the Harris Family Native Title Claims, through the guidance of the South West Aboriginal Land and Sea Council (SWALSC). This follows on from consultation originally undertaken with the groups prior to the development of the Wonnerup mine in 2010.

The Proposal is located in a region mined for mineral sands since the 1970's. The scale of the Proposal, at a throughput of 2.5 Mt of ore per annum over a 15 to 18 month period is relatively small for the industry. The nature of the deposit, being shallow and without overburden, as well as being an extension of existing operations, further reduces its relative scale.

Table of key characteristics

Location	
Tenement	M70/785, held exclusively by Cable Sands (WA) Pty Ltd. Cable Sands (WA) Pty Ltd is wholly owned by Cristal.
Land Ownership	Privately owned by R & S Manning Lot 3819 on Plan 153196, CT2069/Folio595
Local Government	City of Busselton
Nearest main road	Sues Road and Bussell Highway
Development start	2016
Production start	January 2017
Production end	August 2018
Site works complete	First quarter, 2022
Rehabilitation works complete	Second quarter, 2022
Ore processed	2.5 Mt per year, 3.5 Mt in total (2,100,000 bulk cubic metres [bcm])
Overburden removed	506,000 bcm
Total bcm disturbed	2,606,000 bcm
HMC recovered	200,000 t HMC
Power source	From Wonnerup mine site substation supply
Water source	Wonnerup mine production bore
Flocculant	Existing flocculant thickener infrastructure at Wonnerup Mine to be used
Lime	Existing water management and lime dosing system at Wonnerup Mine utilised
Specific requirements	Timing of mining and rehabilitation in vicinity of airport to meet potential airport expansion requirements

List of environmental management and rehabilitation commitments

Potential Environmental impact	Management Commitment Implementation	Timelines
Noise emissions from project activities exceeding regulations and/or causing impacts on nearby premises.	<ul style="list-style-type: none"> Develop and implement a Noise Management Plan for construction and operation phases, based on the predictive noise model and current best practice, to meet the requirements of the Environmental Protection Act and regulations. Design and construct noise bunds prior to start of mining. Select quietest available equipment or modify existing equipment to reduce noise levels. Position pumps and rotary trommels below normal ground surface, where practicable. Continuously monitor noise levels (ambient and directional) around the mine site. Monitor atmospheric conditions to assist in daily noise risk assessments (using Wonnerup facilities) 	<ul style="list-style-type: none"> Design and approvals Construction Operations Design and approvals Construction Operations Operations Construction Operations Backfilling Construction Operations Backfilling
Release of eroded materials or potential contaminants into downstream drainage lines, potentially affecting aquatic biota and the Ramsar listed Vasse-Wonnerup System.	<ul style="list-style-type: none"> Refer proposed Action to DSEWPAC under EPBC Act for assessment of potential significant impacts to Ramsar wetland. Develop and implement a Water Management Plan and Operating Strategy in consultation with DoW, DER and DSEWPAC (based on the currently-approved plan for Wonnerup). Exclude project activities within a 100 m buffer zone along the western bank of the Sabina River (other than within the services corridor crossing the river). Develop and implement emergency spill response procedures. Harvesting of stormwater runoff from disturbed areas and pit dewatering for on-site storage and pumping to the Wonnerup minesite (DER licence L8739/2013/1) for treatment and subsequent re-use or discharge to the Sabina River (existing discharge criteria would continue to apply). 	<ul style="list-style-type: none"> Design and approvals All stages All stages All stages All stages
Pit dewatering reducing Sabina River flows, and/or adversely affecting surface water or groundwater uses.	<ul style="list-style-type: none"> Use URS groundwater model to develop Dewatering Operation Strategy in consultation with DoW. Progressive deposition of tailings behind the mining face to assist with groundwater recharge. Monitor groundwater levels and the health of remnant vegetation to enable issues to be identified prior to impacts occurring. Adopt additional management measures to reduce drawdown, such as artificial recharge to the local aquifer, if required (measures to be identified in consultation with DoW as part of the development of the Dewatering Operation Strategy). 	<ul style="list-style-type: none"> Design and approvals Operations Operations Construction Operations Rehabilitation Operations
Clearing remnant native vegetation potentially resulting in the loss of fauna habitat and foraging areas (such as for the Western Ringtail Possum or Black Cockatoo).	<ul style="list-style-type: none"> Submit native vegetation clearing application that addresses the ten principles for clearing native vegetation outlined in schedule 5 of the Environmental Protection Act. Refer proposed Action to DSEWPAC under EPBC Act for assessment of potential significant impacts to Western Ringtail Possum (WRP) and Black Cockatoo. Adopt controlled clearing procedures that restrict vegetation clearance within approved areas to a practical minimum. Follow WRP clearance protocols. Develop suitable offsets (like for like) on adjacent Wonnerup site (to complement existing offset works already undertaken on that site). 	<ul style="list-style-type: none"> Design and approvals Design and approvals Construction Construction All phases

Potential Environmental impact	Management Commitment Implementation	Timelines
Potential loss of land capability due to soil disturbance.	<ul style="list-style-type: none"> Avoid riparian vegetation (within the 100 m river corridor) and selecting degraded stretch for construction of river crossing. Rehabilitate and improve remnant native vegetation areas cleared by project activities. Develop and implement a Mine Closure Plan that includes closure objectives and criteria that relate specifically to primary productivity of the agricultural land in comparison to unmined sites. Undertake assessments of pasture productivity and soil properties before and after mining, including at control sites. Progressively rehabilitate disturbed areas. Consult regularly with landowner and government concerning site rehabilitation objectives and end land use. 	<ul style="list-style-type: none"> All phases Operations Rehabilitation All stages Design and approvals Rehabilitation All phases All stages
Disturbance of sites of Aboriginal or European cultural significance.	<ul style="list-style-type: none"> Submit Section 18 Notice to DAA regarding construction of services corridor across Sabina River. Contribute to fencing upgrades and replanting efforts on the property along the Sabina River. Undertake archaeological monitoring during construction and implement chance-find procedures. 	<ul style="list-style-type: none"> Design and approvals All stages Construction
Disturbance of acid sulfate soils (ASS) resulting in impacts on groundwater, surface water, soils or vegetation.	<ul style="list-style-type: none"> Implement an ASS Management Plan to the satisfaction of DER and also DSEWPAC. Dewatering Operation Strategy to include management of impacts on dewatering discharge and groundwater due to ASS. Monitor materials as they are mined and processed to enable ASS and potentially ASS materials to be identified, separated and remedial actions to be taken. Monitor surface water and groundwater quality in final rehabilitated landforms where ASS or potentially ASS materials are located. 	<ul style="list-style-type: none"> All stages All phases Construction Operations Operations Rehabilitation
Potential for mining activities to delay or prevent BRA Airport extension.	<ul style="list-style-type: none"> Continue engagement with local government regarding timing of airport redevelopment and land development implications. 	<ul style="list-style-type: none"> Design and approvals Operations
Local amenity impacts due to dust.	<ul style="list-style-type: none"> Develop and implement a Dust Management Plan. Use water carts to reduce dust risk, particularly when stripping surface materials. Monitor dust at the premises boundary and report against internal targets (90 ug/m³ for TSP and 50 ug/m³ for PM10). Consult regularly with landowners concerning amenity issues. 	<ul style="list-style-type: none"> All stages Construction Operations Rehabilitation Construction Operations Rehabilitation All phases
Local amenity impacts due to light spill.	<ul style="list-style-type: none"> Install lighting as per Australian Standard 4282 <i>Control of obtrusive effects of outdoor lighting</i>. Liaise with the City of Busselton and, if required, the Civil Aviation Safety Authority (CASA) regarding light emissions adjacent to the airport. 	<ul style="list-style-type: none"> Design and approvals Operations Design and approvals Operations
Spread of or increase in declared weeds, soil pathogens or feral species (e.g. fox and rabbit).	<ul style="list-style-type: none"> Implement Weed and Pathogen Management Protocol. Implement feral species controls. 	<ul style="list-style-type: none"> All phases Construction Operations Decommissioning and closure
Increase in traffic volumes on local roads and highways.	<ul style="list-style-type: none"> Apart from during the construction phase, the Wonnerup South Project is not expected to result in a net increase in existing mine-related traffic (including concentrate haulage) on local roads or the Bussell Highway. 	<ul style="list-style-type: none"> Construction

Potential Environmental impact	Management Commitment Implementation	Timelines
	<ul style="list-style-type: none"> • Traffic during the construction and operations phases is to be managed as per the management measures implemented for the Wonnerup Mine. 	<ul style="list-style-type: none"> • Construction • Operations

Contents

1	Ownership.....	1
2	Proposal setting	2
2.1	Location.....	2
2.2	Proposed activities.....	2
2.3	Existing facilities.....	2
2.4	Post-mining	3
2.5	Land tenure and planning	3
2.6	History.....	3
3	Existing environment	11
3.1	Regional setting.....	11
3.2	Climate	11
3.3	Geology	12
3.4	Topography.....	12
3.5	Proposal resource	12
3.6	Soil profiles and types.....	13
3.7	Water resources.....	17
3.8	Vegetation and flora	27
3.9	Fauna.....	28
3.10	Aboriginal heritage.....	36
3.11	Surrounding land use	37
3.12	Near neighbours.....	37
3.13	Neighbourhood noise	37
4	Proposal description	41
4.1	Area of disturbance.....	41
4.2	Site development	41
4.3	Mining operations.....	45
4.4	Support facilities	46
4.5	Workforce	46
4.6	Compliance with legislation and other approvals	47
5	Environmental impacts and management.....	48
5.1	Overview	48
5.2	Approach to environmental impact assessment	48
5.3	Environmental management framework.....	49
5.4	Relevant factors	50
5.5	Vegetation and flora	52
5.6	Fauna.....	53

5.7	Surface water	54
5.8	Groundwater.....	56
5.9	Acidic sulfate soils	61
5.10	Noise and vibration.....	62
5.11	Visual amenity and light.....	62
5.12	Dust emissions	63
5.13	Hydrocarbon/chemical use	64
5.14	Radiation	65
5.15	Waste management.....	66
6	Social impacts and management	67
6.1	Aboriginal heritage.....	67
7	Rehabilitation and closure	68
7.1	Mine Closure Plan	68
7.2	Timeline.....	68
7.3	Final land use and closure concepts	69
7.4	Decommissioning and rehabilitation activities.....	70
8	References	73

Figures

Figure 1: Wonnerup South Mining Proposal - regional setting	5
Figure 2: Wonnerup South Mining Proposal - proposed layout.....	7
Figure 3: Surrounding residences and planning policy zones.....	9
Figure 4: Summary of climatic data for Busselton Meteorological Station (No. 009515)	11
Figure 5: Acid sulfate soil test hole locations (Aurora 2013)	15
Figure 6: Sabina River modelled monthly flow and average rainfall 1980-2006 (DoW 2009b)	17
Figure 7: Sabina River foreshore condition, adjacent to Proposal site.....	21
Figure 8: Sabina River revegetation works on Lot 3819, near Bussell Highway, carried out by GeoCatch in early 2013	21
Figure 9: Surface water features and monitoring locations	23
Figure 10: Mapped wetlands of the Proposal site.....	25
Figure 11: Wonnerup South Proposal – mapped vegetation communities	29
Figure 12: Photographs of the four vegetation communities mapped by Ekologia (2012)	31
Figure 13: Fauna field survey results for Wonnerup South	33
Figure 14: Registered sites of Aboriginal significance.....	39
Figure 15: Proposed native vegetation clearing requirements	43
Figure 16: Predicted maximum drawdown distribution (URS 2013).....	59

Tables

Table 1: Proposal tenement details	1
Table 2: Background water quality for the Sabina River	18
Table 3: Groundwater quality monitoring results (from Aurora 2013)	20
Table 4: Native remnant vegetation associations in the Proposal site.....	27
Table 5: Background noise at two locations within 1 km of the Wonnerup South site	38
Table 6: Area of Disturbance Wonnerup South Proposal M70/785.....	41
Table 7: Environmental approvals for the Proposal (not exhaustive)	47
Table 8: Responsibilities prescribed by the Cristal EMS	49
Table 9: Assessment against the Native Vegetation Clearing Principles	51
Table 10: Conceptual timeline (dependent on environmental assessment outcomes).....	68

Attachments

Attachment 1: Landowner agreement

Attachment 2: Acid Sulfate Soil Investigation and Management Plan (Aurura 2013)

Attachment 3: Wetland Buffer Investigation (Ecosystem Solutions 2012)

Attachment 4: Vegetation, Flora and Wetland Survey (Ekologica 2012)

Attachment 5: Groundwater Environmental Impact Assessment, including Addendum (URS 2008 and 2013)

Attachment 6: Targeted fauna assessment Sabina Vale (Harewood 2013)

1 Ownership

Cristal Mining Australia Ltd (Cristal) is the sole owner of Cable Sands (WA) Pty Ltd (Cable Sands), which is the oldest titanium mineral mining company in Western Australia and has operated in the South West since 1956. Mining on Koombana Bay and Turkey Point in Bunbury occurred until the mid-1960s. Subsequent mining has occurred at Ambergate, Stratham, Wonnerup, Busselton, Capel, Jangardup, Yarloop, Benger, Tutunup, Ludlow and Waroona.

The Wonnerup South Mineral Sands Mining Project (the Proposal) will be operated by Cristal and all agreements and approvals will be made in that company name. This notwithstanding, both identities are valid and applicable, with the preference being for Cristal to be designated as the controlling entity.

The ownership and contact details for the Proponent are as follows.

Company Name: Cristal Mining Australia Ltd
Address: PO Box 133 Bunbury WA 6231
Telephone: 08 9721 0200
Facsimile: 08 9791 1249
ACN: 009 137 142
Company Contact: Phil Johnston (SHE Manager)
Email: Phil.Johnston@cristal.com

The Proposal tenement details are provided below (Table 1).

Table 1: Proposal tenement details

Lease	Purpose	Holder	Area (ha)	Status
M 70/785	Mineral sands mining	Cable Sands (WA) Pty Ltd	411	Active

2 Proposal setting

2.1 Location

The Proposal is located 50 km southwest of Bunbury and approximately 6 km east-southeast of Busselton in the southwest of Western Australia (Figure 1). It is bound by the Bussell Highway to the north and Sues Road to the east, with access to the operations off Sues Road. The closest townsite, as defined by the *Land Administration Act 1997*, is Wonnerup, which is 2.3 km from the Proposal.

The Proposal is adjacent to Cristal's Wonnerup Mine, which commenced operations in 2013. The two mines will share core infrastructure and power and water supplies (see section 2.3).

The Sabina River flows northwest between the Proposal and the adjacent Wonnerup mine. The Sabina River discharges into the Ramsar-listed Vasse Wonnerup wetland system, 2 km to the north. The Busselton Regional Airport (BRA) is located immediately to the southwest of the Proposal site.

2.2 Proposed activities

The Proposal comprises a large central/southern pit with a small northern satellite pit, together with topsoil stockpiles, solar evaporation ponds (SEPs) and associated internal roads and pipelines (Figure 2). Over the life of the Proposal, 3.5 million tonnes (Mt) of ore will be mined for primary wet separation at the adjacent Wonnerup mine to produce an estimated 200,000 tonnes of Heavy Mineral Concentrate (HMC), which will then be trucked to the Cristal North Shore secondary processing plant to separate the HMC into its component streams, prior to export through the Port of Bunbury. Sand tailings and clay fines from the wet separation and water treatment processes will be returned to the Proposal site for backfilling of the mine pits.

The Proposal will directly disturb up to 190 ha out of a tenement area of 411 ha, the vast majority of which is cleared farmland. Development will begin in early 2016, with production commencing in 2017. Mining would be completed in about 20 months and progressive rehabilitation activities would continue, involving the backfilling of the mining voids with combined sand and clay (fines) tails, surface contouring and the re-establishment of either pasture or native vegetation, as per the closure requirements.

Water, power and other services will be sourced from the Wonnerup mine (see section 2.3) via a services corridor running between the two sites and crossing the Sabina River.

2.3 Existing facilities

The Proposal is an extension of the current Wonnerup mineral sands mine (Figure 2), which has been in production since early 2013. The Wonnerup mine is located on land that does not fall under the *Mining Act 1978* (i.e. it is 'mineral to owner' and subject to the *Planning and Development Act 2005*, as well as other legislative controls including the *Environmental Protection Act 1986* and the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*).

The Proposal will utilise the following facilities at Wonnerup:

- production well (groundwater)
- water storage, treatment, distribution and disposal facilities
- wet processing plant
- area for initial or contingency tailings storage
- HMC stock-piling and load-out facilities
- administration and maintenance facilities.

HMC produced by the wet processing plant will be trucked from Wonnerup along the existing approved route (Sues Rd, Bussell Highway and Robertson Drive) to the Bunbury mineral separation plant at North Shore (G70/83).

2.4 Post-mining

With the very short productive mine life and shallow deposit, rehabilitation works are expected to be completed three years after the completion of mining. If applicable at the time, areas required for the BRA expansion will be mined and rehabilitated as a priority. The remainder of the site is expected to be reinstated to productive grazing land, with the exception of areas that will be rehabilitated to native vegetation to replace the trees and remnant vegetation cleared as part of the Proposal.

All services and infrastructure will be removed once it is no longer required, with the exception of the Sabina River crossing, which will be left for the use of the landowner, following an engineering assessment of its condition.

2.5 Land tenure and planning

The Proposal lies entirely within the City of Busselton, in the Locality of Yalyalup and is located on a single property, Lot 3819 on Plan 153196, which is owned by R & S Manning and is used for agricultural purposes and supports two residences (Figure 2).

There is a semiurban residential development to the west of the site ('Provence'), located 1.5 km from the edge of the proposed operations and 1 km from the edge of the tenement (Figure 3). There are also several small landholders to the north of Bussell Highway ('Reinscourt'), the closest of which is 1.2 km from the edge of proposed operations. Land to the east of the site is currently under the Wonnerup mine; land to the south west forms part of the BRA and land to the south is agricultural.

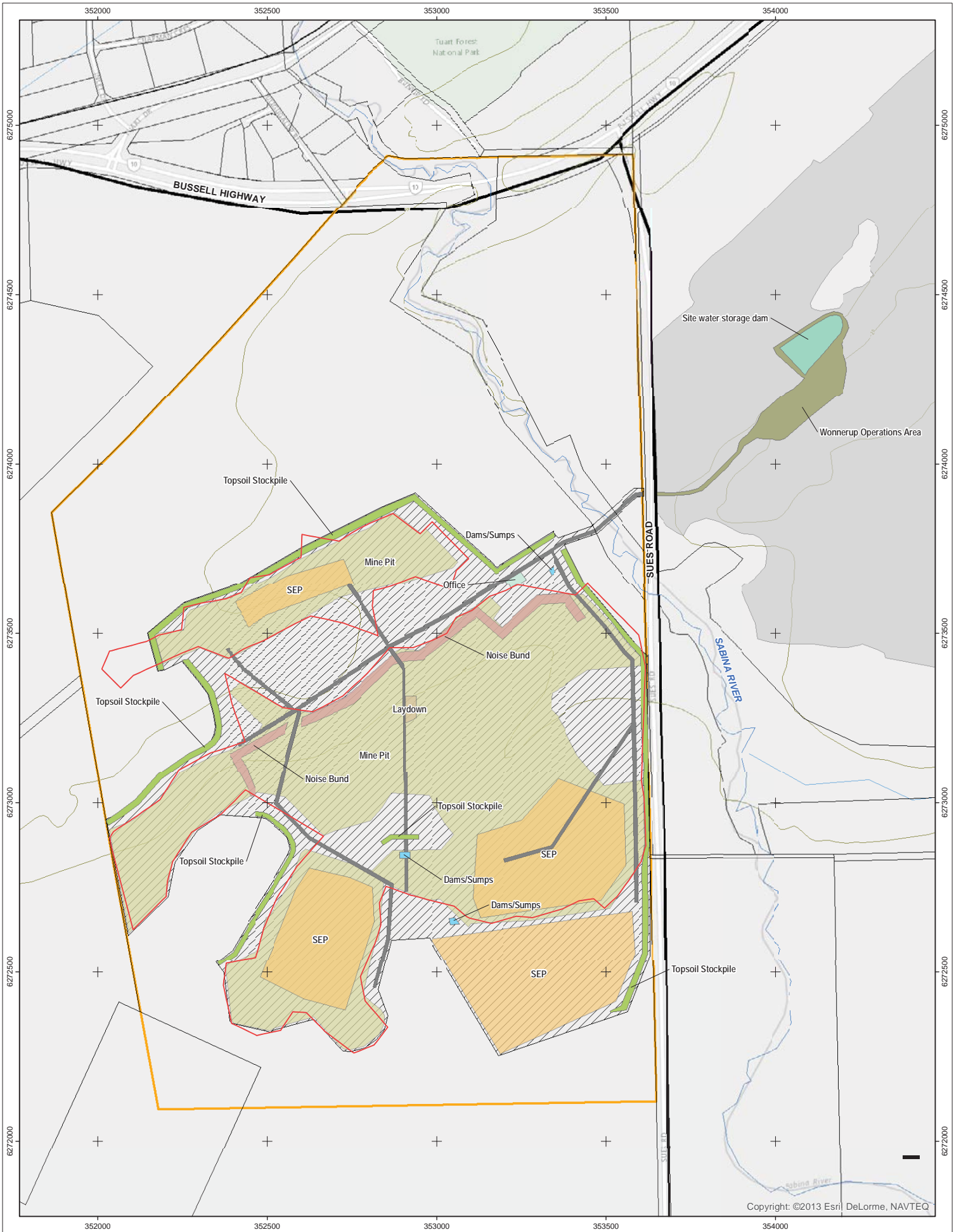
The Proposal site would normally come under the City of Busselton Town Planning Scheme No 20, where it is zoned as 'Agriculture'. The City has been consulted on the Proposal and does not require a separate planning approval for mining activities that are conducted on *Mining Act 1978* tenure.

2.6 History

RGC Mineral Sands Ltd (RGC) conducted drilling over the Wonnerup South deposit (Figure 2) prior to 1998, before merging with Westralian Sands later in 1998 to create Iluka Resources Ltd (Iluka). With Iluka's permission, a drill program was carried out by Bemax Resources Ltd in 2006 to verify the RGC data and to provide mini-bulk samples for mineralogical test work. Bemax's assay results were found to be comparable to RGC's, however, no final agreement was reached regarding the mining or transfer of the tenement (M70/785).

In 2011, the tenement was transferred (sold) to Simto Resources Ltd and then on-sold with a number of other tenements to Cristal Mining (as Cable Sands (WA) Pty Ltd) in 2012.





WONNERUP SOUTH

Wonnerup South Project
Proposed Mine Layout
Figure 2

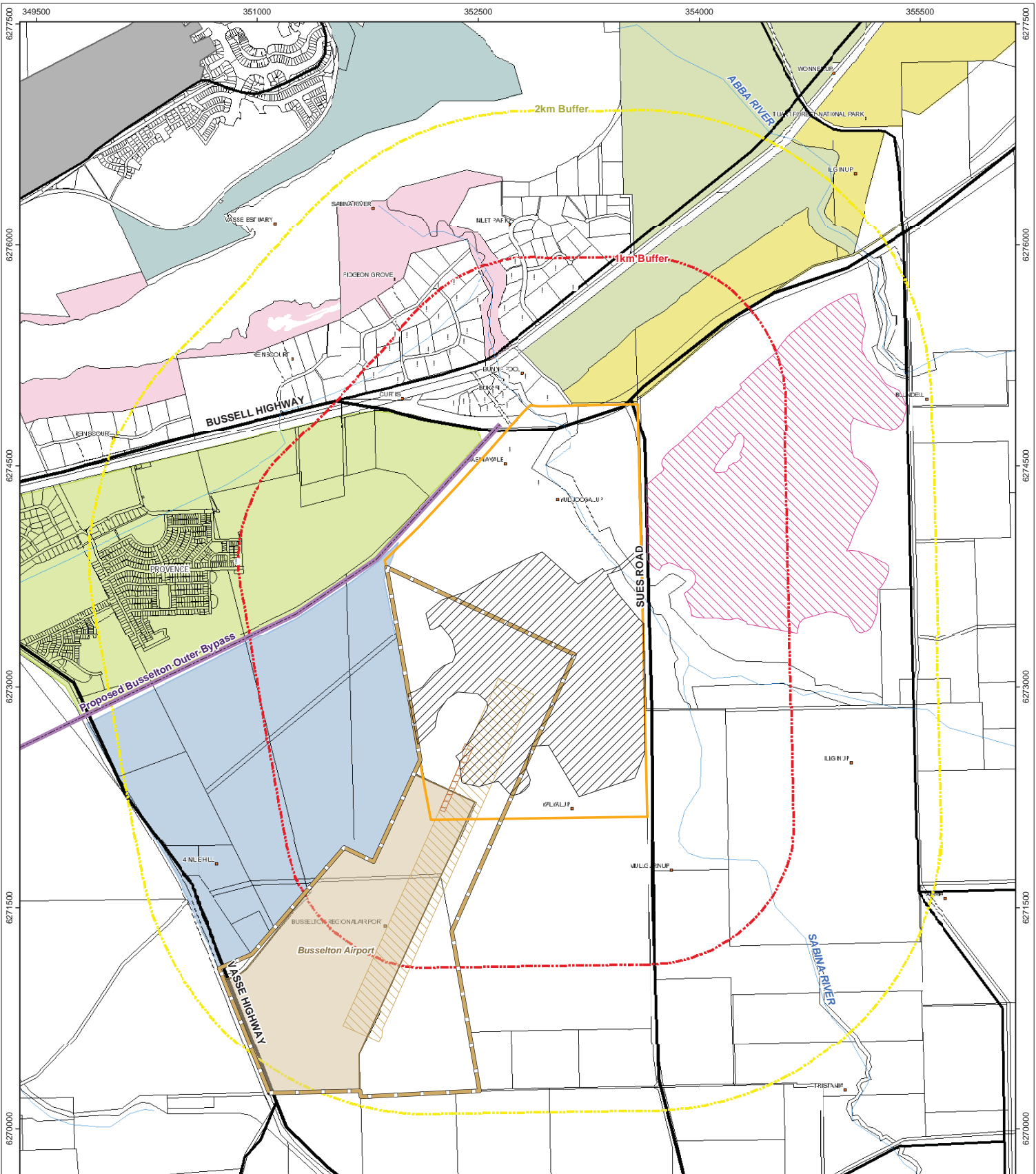


Meters
1:10,000

Datum: GDA94 Projection: MGA Zone 50

Legend

- Wonnerup Development Area
- Wonnerup South Resource
- Wonnerup Operations Area
- Site water storage dam
- Dams/Sumps
- Topsoil Stockpile
- Internal Roads
- Office
- Noise Bunds (Ore)
- SEP
- Laydown
- Mine Pits
- Wonnerup South Mine Development Area
- Mining Tenement M70/785



Legend		Mining		Airport		Yalyalup Development Areas		DEC Managed Lands & Waters	
	Major Road		Mining		Current Busselton Airport		Commercial		5(1)(h) Reserve
	Secondary Road		1km M70/785 Buffer		New Boundary		Residential		National Park
	Minor Road		2km M70/785 Buffer		Extension		Residence Locations within 1km		Nature Reserve
	Other Road / Tracks		Wonnerup South Mine Development Area		New Airstrip				State Forest
	Proposed Busselton Bypass		Wonnerup Development Area						

Figure 3

3 Existing environment

3.1 Regional setting

The South West region of Western Australia is an important mining, processing, agricultural, manufacturing, timber and tourism region. Titanium minerals (heavy mineral sands) are mined at various locations along the coastal plains of the region. The mineral sands mining industry is regionally significant, employing a workforce centred around the Bunbury, Capel and Busselton areas and making extensive use of local services, including those based in or employing staff from the Busselton area (SWDC 2010).

The region also includes Western Australia's main centres for the dairy, horticulture and timber industries. Bunbury acts as a service city and port for the industries within the area. The greater Bunbury area has a population of over 50,000 people (SWDC 2010).

3.2 Climate

The region experiences a Mediterranean climate with hot, dry summers and mild, wet winters. The nearest Bureau of Meteorology weather station is at the neighbouring BRA facility (operating since 1997), however the Busselton weather station¹ has over 100 years of records and is located approximately 6 km northwest of the Proposal. Records from this station show that median rainfall is 805 mm and approximately 93% of this is experienced between April and November.

Average maximum temperatures range from 16.3°C in July to 28.5°C in January. Average minimum temperatures range from 7.5°C in July/August to 14.0°C in February (Figure 4). Winter storms bring squally winds from the northwest to southwest. During summer, south westerly sea breezes occur in the afternoon, while hot dry easterly winds of moderate strength occur at night and early in the day.

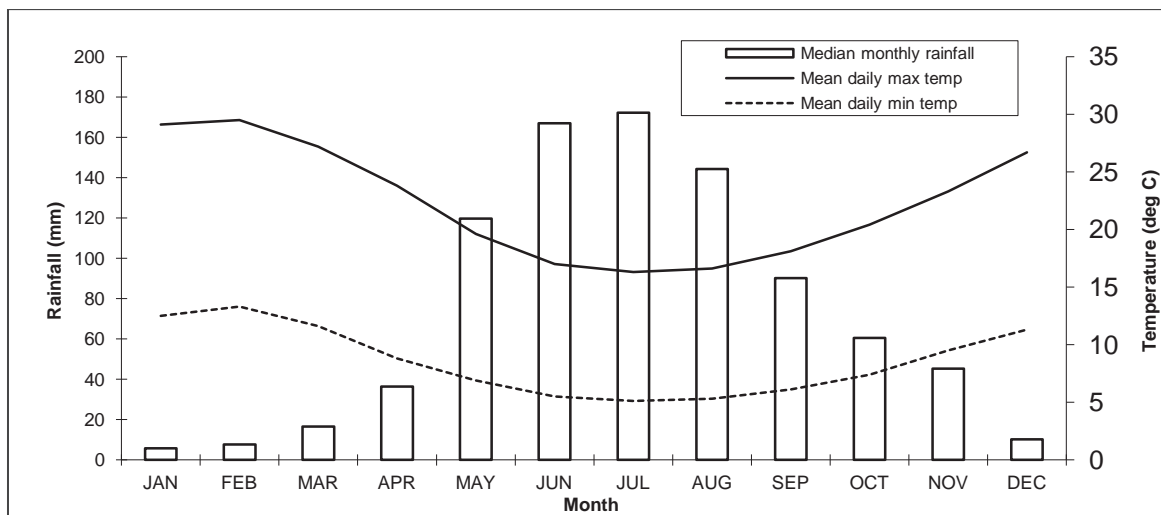


Figure 4: Summary of climatic data for Busselton Meteorological Station (No. 009515)

¹ Busselton Shire: Bureau of Meteorological Station No. 009515, Latitude: 33.66 °S Longitude: 115.35 °E, Elevation 4 m. Operational since 1877. (Source: BOM http://www.bom.gov.au/climate/averages/tables/cw_009515.shtml (accessed 6/06/2013)).

3.3 Geology

According to the *Wonnerup South Acid Sulfate Soil Investigation and Management Plan* prepared for Cristal by Aurora Environmental (Attachment 2), the *Busselton Environmental Geology Sheet* (Belford, 1987) indicates the predominant surface geology within the Proposal site comprises Unit S8, Bassendean Sand (see Figure 4 of Attachment 2). The unit has been described as very light grey at surface, yellow at depth, fine to medium-grained, sub-rounded quartz, moderately well-sorted, of eolian origin. Regionally, the Bassendean Sand unit is generally flat to gently sloping (up to 10°), with an elevation of between 10 mAHD² and 32 mAHD. This unit is known to host local accumulations of heavy minerals, such as ilmenite and leucoxene, as well as sulfides.

Unit Ms2, sandy silt of the Guildford Formation, is mapped as being present across the northern half of the site. The Guildford Formation unit has been described as strong brown to mid-grey, mottled, blocky, containing disseminated fine sand, hard when dry, and being of alluvial origin. Regionally, Unit Ms2 is flat-lying (less than 3° slope) with elevation of between 5 mAHD and 12 mAHD.

The Sabina River, located in the northeast corner of the site, is shown in the Geology Sheet as being hosted by Unit Msc1, clayey sandy silt, which is described as comprising pale brown, angular to rounded sand, with low cohesion and of alluvial origin. This alluvial unit follows the alignment of the Sabina River with a gentle slope of approximately 3° within the site. An area of river floodplain is associated with the present location of the Sabina River.

3.4 Topography

The topography of the Wonnerup South tenement M70/785 is relatively flat, rising gently from approximately 10 mAHD in the north of the tenement to 15-20 mAHD to the south of the tenement, with very slight depressions and rises through the site (Attachment 3).

3.5 Proposal resource

The Wonnerup South deposit is part of the Capel palaeo-shoreline (Baxter 1977) which is marked by an arcuate ridge parallel to and about 7 km inland from the present coast. Other heavy mineral deposits on this shoreline include Amber Farm, strands C and D at Busselton, Location 7, Ruabon, Higgins, Prowse and the Capel deposits.

Two northeast-striking zones of heavy mineral sands are present at the Wonnerup South deposit (Figure 2). The northern-most strand is flat-lying, with a base at 4 – 5 mAHD and sits directly on the Leederville Formation in places. The larger central ore zone consists of a heavy mineral strand at 8 – 10 mAHD with wind-blown ore at 10 – 13 mAHD immediately inland from the strand. The wind-blown ore material gradually decreases in thickness along the gently northwest-dipping basement away from the strand ore.

The JORC compliant Measured Resource³ of the Wonnerup South heavy mineral sand deposit is 3.8 million tonnes @ 6.0% heavy mineral and 15.4% slimes. The average mineral suite of economic heavy minerals is 73.9% ilmenite, 6.9% secondary ilmenite, 7.5% leucoxene and 9.9% zircon.

² mAHD: metres above Australian height datum (AHD), which is a zero elevation reference point that uses mean sea level. See <http://www.ga.gov.au/earth-monitoring/geodesy/geodetic-datums/australian-height-datum-ahd.html>

³ The Wonnerup Resource Estimate has been classified in the 'Measured' category, as defined in the 2012 edition of the Australasian Code for Reporting of Exploration Results, Mineral Resources and Ore Reserves [the JORC Code].

3.6 Soil profiles and types

3.6.1 Soil types

The soils of the Proposal site have been described by Ecosystems Solutions Pty Ltd in its 2012 site wetland survey (Attachment 3). The survey shows that the site has been mapped as the Abba Plain land system - a depositional feature formed of Quaternary alluvium, lying between 10 – 40 m above sea level and containing extensive areas of poor drainage.

The dominant landform pattern is an intricate patchwork of slight depressions and slight rises. The deeper depressions may become inundated in winter, while the rises tend to suffer subsoil waterlogging.

The northern third of the mining tenement has soils belonging to the Cokelup wet clayey flats mapping unit. The centre of the tenement is traversed in an east-west direction by a narrow band of sandy soil belonging to the Bassendean soil-landscape system (overlying the Abba Plain system) on a southwest to northeast axis. The southern portion of the tenement has sandy grey brown duplex (Abba) and gradational (Busselton) soils of the Abba wet flats and Abba flats mapping units.

The mining tenement lies mostly within the Bassendean Dunes System, which in this area consists of gently sloping low dunes and rises with well-drained, deep, leached grey sands.

3.6.2 Acid sulfate soils

Aurora Environmental (Aurora) was engaged by Cristal to investigate the potential presence of acid sulphate soils (ASS) for the Proposal (Attachment 2). The investigation was conducted in accordance with the relevant government guidelines and in consultation with the (then) Department of Environment and Conservation (DEC⁴) Acid Sulfate Soils Branch⁵.

Desktop review

At a regional scale, the majority of the Proposal site is mapped as being at “moderate to low risk of ASS occurring within 3 m of natural soil surface” (Landgate 2013). The Sabina River alignment in the northeast corner of the site is mapped as “high to moderate risk of ASS occurring within 3 m of natural soil surface” (Landgate 2013).

The adjacent Wonnerup minesite, which is the same geology and soil types and is also traversed by the Sabina River, was assessed for potential acid sulphate soils prior to mine development by Coffey Environments. The investigation report (2010a) found that:

- about 20% of the 544 soil samples had acid generating potential in excess of the DEC criterion of 0.03 percent sulfur content (%S) for Bassendean Sands
- the distribution of high-sulfur samples could not be readily correlated with lithologies, soil types, depth to groundwater or previous mining activities on the site
- groundwater had a near neutral pH range (6.4 - 7.9) and contained varying levels of total alkalinity (range of 21 mg/L to 190 mg/L (as CaCO₃)).

Assessment criteria

When considering whether sufficient pyrite exists to present a significant risk of oxidation by mineral sands mining activities, DER uses the following assessment criteria (DEC 2012):

- field pH (pH_F) less than four in more than 10% of borehole locations; and /or
- field oxidation pH (pH_{FOX}) less than three in more than 10% of the samples tested.

⁴ Now Department of Environmental Regulation (DER)

⁵ Mining for mineral sands in the southwest of WA is generally managed through the DEC (2012) guideline *Investigation and Management of Acid Sulfate Soils and Water in Acid Sulfate Soil Landscapes* rather than the DMP guidance (2009) on Acid Mine Drainage.

Should either of these assessment criteria be triggered, then active management of soil and water will likely be required after mining to mitigate the risk of further environmental harm.

Field and laboratory assessment

The assessment of the Proposal site found that there were only limited and sporadic areas containing actual and potential ASS. As shown in Attachment 2, none of the 50 samples collected and tested from six boreholes across the deposit (Figure 5) returned a pH_F of less than 4. Only two of the samples collected returned a pH_{FOX} of less than 3 (i.e. 4% of samples). Overall, the study found that the soils of the proposal site were within the DEC (2012) criteria and active management would not be required (see section 5.9).

Groundwater indicators

Groundwater had a lower pH (5.6-6.7) but slightly lower acidity values (13 mg/L to 120 mg/L). This aspect is discussed further in section 3.7.2.

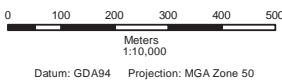
3.6.3 Contaminated site identification

The Proposal site is currently used for agricultural purposes (beef and dairy farming), which is a potentially contaminating activity according to the DER (DoE 2004).

A preliminary/screening contamination risk assessment has been undertaken, in accordance with the DER Guideline *The Use Of Risk Assessment In Contaminated Site Assessment And Management* (2006). The overall risk was assessed as low, with the most prominent risk factor being the storage and handling of agricultural chemicals and above-ground diesel fuel storage. The site where farm chemicals and fuel are stored, which is outside of the proposed development area, showed no indications of excessive leaks or spills.



WONNERUP SOUTH
Wonnerup South Project
Acid Sulfate Soil Test Hole
and Monitorin Bore Locations
Figure 5



- Legend**
- A** ASS Test holes 2013
 - F** Groundwater Monitoring bores
 - Orange outline** Mining Tenement M70/785
 - Blue outline** 50cm Drawdown
 - Red hatched** Proposed Mining Pits

3.7 Water resources

A background review of available surface and groundwater quality data was prepared by Coffey Environments in 2010 as part of the approvals process for the Wonnerup mine (Coffey Environments 2010b). This study collated and interpreted data from various sampling programs conducted at the Wonnerup site including:

- historical surface water data collected on the Sabina River by relevant government departments between 1972 and December 2009
- surface water samples collected by Cristal between July 2009 and December 2009
- groundwater quality data collected by Cristal, Coffey Environments and Iluka between December 2006 and December 2009
- the groundwater environmental impact assessment for the Wonnerup mine (URS 2008).
- Department of Water (DOW) flow and nutrient modelling within the Vasse-Wonnerup catchment (DoW 2009a, 2009b).

The information presented in Coffey Environments (2010b) as it relates to the Proposal is summarised in the following sections, and supplemented by additional references.

3.7.1 Surface water

Hydrology

The Sabina River flows north through the tenement (Figure 2) before discharging into the Vasse-Wonnerup Wetland system 2 km further downstream. The river has been heavily modified, with flow from the upper reaches being diverted to the Vasse Diversion Drain from a point approximately 4 km upstream of the Proposal site. The catchment below the Vasse Diversion has an area of 49 km² (URS 2008).

Along its length, the Sabina River contains occasional pools that retain standing water throughout the summer months. These pools are inferred to be groundwater dependent on a seasonal basis and most likely act as a source of groundwater recharge during the winter months (URS 2008).

There is no river gauging station on the Sabina River; instead, the DoW has modelled monthly flows based on average monthly rainfall from 1980-2006 (Figure 6). Flow in the river is seasonal, typically occurring between May and October. According to the flow modelling, average annual discharge is approximately 11 GL (DoW 2009b).

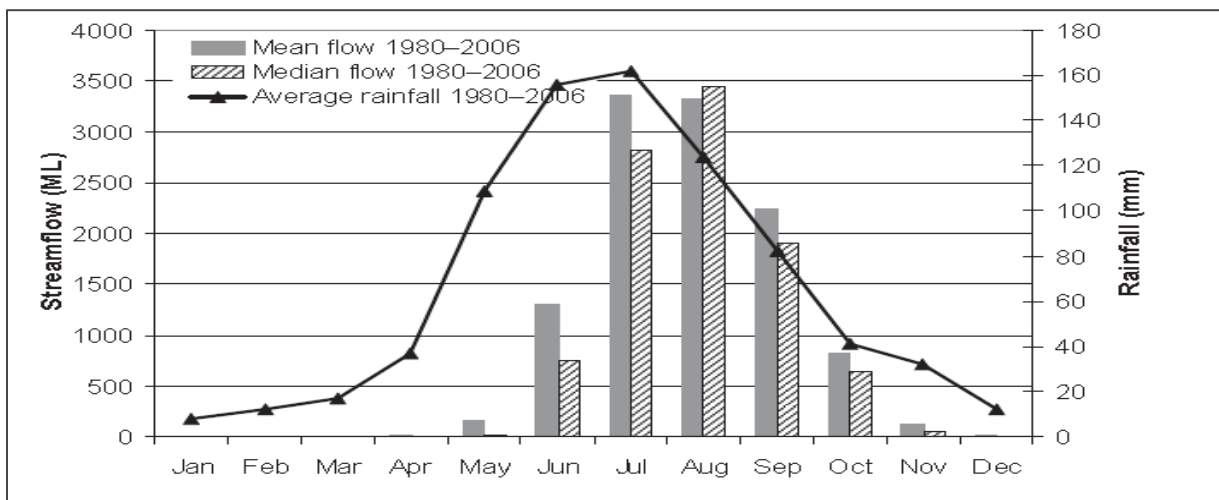


Figure 6: Sabina River modelled monthly flow and average rainfall 1980-2006 (DoW 2009b)

Water quality

The information assessed by Coffey included data from a designated water quality sampling point (site 6101007) operated by DoW since 1972 on the Lower Sabina River. The sampling point is located approximately 600 m north (downstream) of the Proposal site, near the intersection of Bussell Highway and Sues Road. DoW's sampling program is focussed on detecting sources of nutrient discharge due to the potential for raised nitrogen and phosphorous levels to stimulate algal growth in the Vasse-Wonnerup wetlands and epiphytic growth in Geographe Bay.

The first three columns of Table 2 below show typical values for key water quality parameters in the Sabina River compared with relevant criteria including the ANZECC (2000) water quality assessment criteria for short term irrigation and protection of estuaries. The data indicates that salinity (EC) is generally higher and sometimes much higher than the trigger values and that dissolved oxygen often falls below the ANZECC trigger of 80%.

In August 2009, Cristal established a monthly and quarterly surface water sampling program for seven surface water monitoring locations near the Wonnerup mine. Three of these locations (WOSW03, WOSW04 and WOSW05) are located on the Sabina River and of relevance for the Proposal (Figure 9). The results of this program have been summarised and incorporated into Table 2.

Table 2: Background water quality for the Sabina River

Parameter	Coffey 2010b results	Target/Guideline	Cristal Monitoring Results Average (2009-2013)
pH	6.3 - 8.6	-	6.9
EC (μ S/cm)	274 - 3250	120 – 300 ^a	1624
DO (%)	9 - 116	80 – 120 ^a	NS
TSS (mg/L)	1 - 44	NS	12 mg/L
Total P (t/yr)	0.14 ^b (median 0.55mg/L)	0.05 ^b	0.40 mg/L
Total N (t/yr)	1.58 ^b (median 2.7 mg/L)	0.46 ^b	2.5 mg/L

a – Default trigger values for Lowland Rivers in South-west Australia, ANZECC Guidelines (2000).

b – % of nutrient loads calculated from annual loads for the Sabina catchment modelled by the DoW using SQUARE model.
NS – value not specified

River and catchment condition

The Sabina catchment below the Vasse Diversion Drain has largely been cleared for agriculture (Coffey 2010b). The most recent official assessment of the condition of the Sabina River and its catchment was conducted for the preparation of the River Action Plan (WRC 2002a). The assessment of the lower reaches that flow through the Proposal site mapped the area as degraded, due to its ongoing erosion and weed infestation (Figure 7). Some work has been done by the local catchment group and the landowner to address the poor status of the waterway by fencing sections to exclude cattle and planting native species along the watercourse (Figure 8).

A more recent assessment by Onshore Environmental Consultants Pty Ltd (Onshore 2009) rated the river vegetation as 'degraded' on the vegetation condition scale used in Bush Forever (Keighery 1994), owing to the absence of vegetation structure and high composition of introduced plants.

Other users

There are no registered downstream users of the Sabina River however a number of residences are located alongside the river, closer to the Vasse-Wonnerup estuary (Figure 3).

3.7.2 Groundwater

Groundwater resources in the Wonnerup area are contained within the Busselton-Capel Subarea (Superficial & Leederville) and Busselton-Yarragadee (Yarragadee) subareas of the Busselton-Capel

Groundwater Area, and are managed by DoW. The hydrogeology of the area has been described by URS (Attachment 5) and is summarised below.

Superficial aquifers

The superficial formations underlying the proposal area form a highly variable unconfined and semi-confined aquifer system up to 40 m thick (10-15 m thick near the deposit – URS 2008). Bassendean sands comprise a discontinuous unconfined water table aquifer that is directly recharged by rainfall infiltration. Beneath this, the Guildford formation forms a multiple-layer inhomogeneous, anisotropic, and, in places, semi-confined aquifer (see Figure 12 of Attachment 5).

Sand beds form the most significant aquifer zones and predominantly control groundwater flow, although the Guildford formation may also form the water table aquifer depending on the thickness of the Bassendean deposits and depth to the water table.

Leederville aquifer

Recharge of the Leederville aquifer occurs in the Blackwood Plateau, which is located to the south of the Whicher Scarp. Groundwater flow is towards the coast. The upper carbonaceous mudstones/shale beds are of low transmissivity and form a confining layer that limits the vertical hydraulic connection with the overlying superficial formations. Mining is associated with the superficial formations and will not intersect the Leederville aquifer.

Yarragadee aquifer

For the purpose of water resource management, the Yarragadee aquifer is considered to include water contained within both the Yarragadee and the Cockleshell Gully formations, as these flow-systems are hydraulically connected. Recharge to the Yarragadee aquifer generally occurs by downwards leakage from the Leederville aquifer, particularly in the northern half of the Blackwood Plateau. The flow pattern for ground water within this aquifer is similar to the Leederville aquifer, generally trending towards the coast. Discharge from the formation is thought to occur offshore and also by upwards leakage into the Leederville aquifer near the coast.

Although mining will also not intersect this aquifer, the Wonnerup production bore is screened in the Yarragadee.

Other Users

A search of the DoW groundwater bore database shows that there are no superficial groundwater users within a 0.5 km radius of the Proposal site, which is well beyond the predicted extent of influence (see Section 5.8).

Groundwater quality

Cristal has established eight groundwater monitoring bores around the Wonnerup South site (Figure 5). Six of these are screened in the superficial aquifer to describe and track groundwater levels and quality at locations selected to be of most relevance to the mine, any native vegetation and to the Sabina River. Two of the bores are screened below the superficial aquifer and into the Leederville Formation to monitor for down-ward leakage of any groundwater effects. Groundwater in the superficial bores was sampled as part of the ASS study (Attachment 2) and the results are shown in Table 3. Results indicate that water quality varies across the site, with the poorer quality results coming from bores in the southwest area of the site.

Table 3: Groundwater quality monitoring results (from Aurora 2013)

Bore	Depth mbgl	RL mbgl	pH	TDS mg/L	Acidity mg/L	Alkalinity mg/L	Chloride mg/L	Sulfate (mg/L)	Aluminium mg/L	Arsenic mg/L	Iron mg/L	Zinc mg/L
MB18	6.8	1.8	7.4	410	13	100	150	51	<0.01	<0.001	0.88	<0.005
MB19	2.8	1.7	insufficient sample									
MB20	4.0	0.6	5.8	700	42	14	140	35	1.1	<0.001	0.7	0.015
MB21	4.6	0.7	5.8	850	55	16	430	120	0.02	<0.001	11	<0.005
MB22	4.2	2.9	6.7	870	120	87	170	65	1.4	0.081	1.0	<0.005
MB23	7.2	2.5	7.0	1800	39	130	810	82	0.02	0.002	0.24	<0.005

3.7.3 Wetlands

Vasse-Wonnerup System

The Vasse-Wonnerup Wetland system located 2 km downstream of the Proposal site (Figure 1) is fed in part by the Sabina River and is listed under the Ramsar convention as a wetland of international importance due to its habitat for waterbirds. The wetland system has experienced severe nutrient problems for many years including sudden mass fish deaths, blooms of macroalgae, toxic phytoplankton, nuisance odour and mosquito problems (DoW 2009b). Limited flushing opportunities arising from the installation of floodgates at the mouth of the estuaries is likely to have increased the susceptibility of this system to nutrients (DoW 2009b). The wetland system comes under the responsibility of a number of different government agencies and management plans are in effect, including the draft Water Quality Improvement Plan issued by the DoW in 2009.

Regional and site wetland mapping

The majority of the mining tenement is mapped in the WA Government's wetlands dataset as 'multiple use Palusplain' or 'multiple use dampland'. Wetlands falling into the 'multiple use' management category are considered to have few important ecological attributes and functions remaining and to be generally suitable for agricultural purposes (Attachment 3). A Palusplain is an area that becomes seasonally waterlogged, whereas a dampland is a seasonally waterlogged basin wetland where the soils beneath the surface are saturated but the water does not inundate the soil surface (WRC 2001).

Ecosystem Solutions conducted a site-specific survey of the wetlands and their area of influence within the Wonnerup South deposit. The hydrological boundaries of the wetlands were surveyed to confirm mapping and are shown in Figure 10.

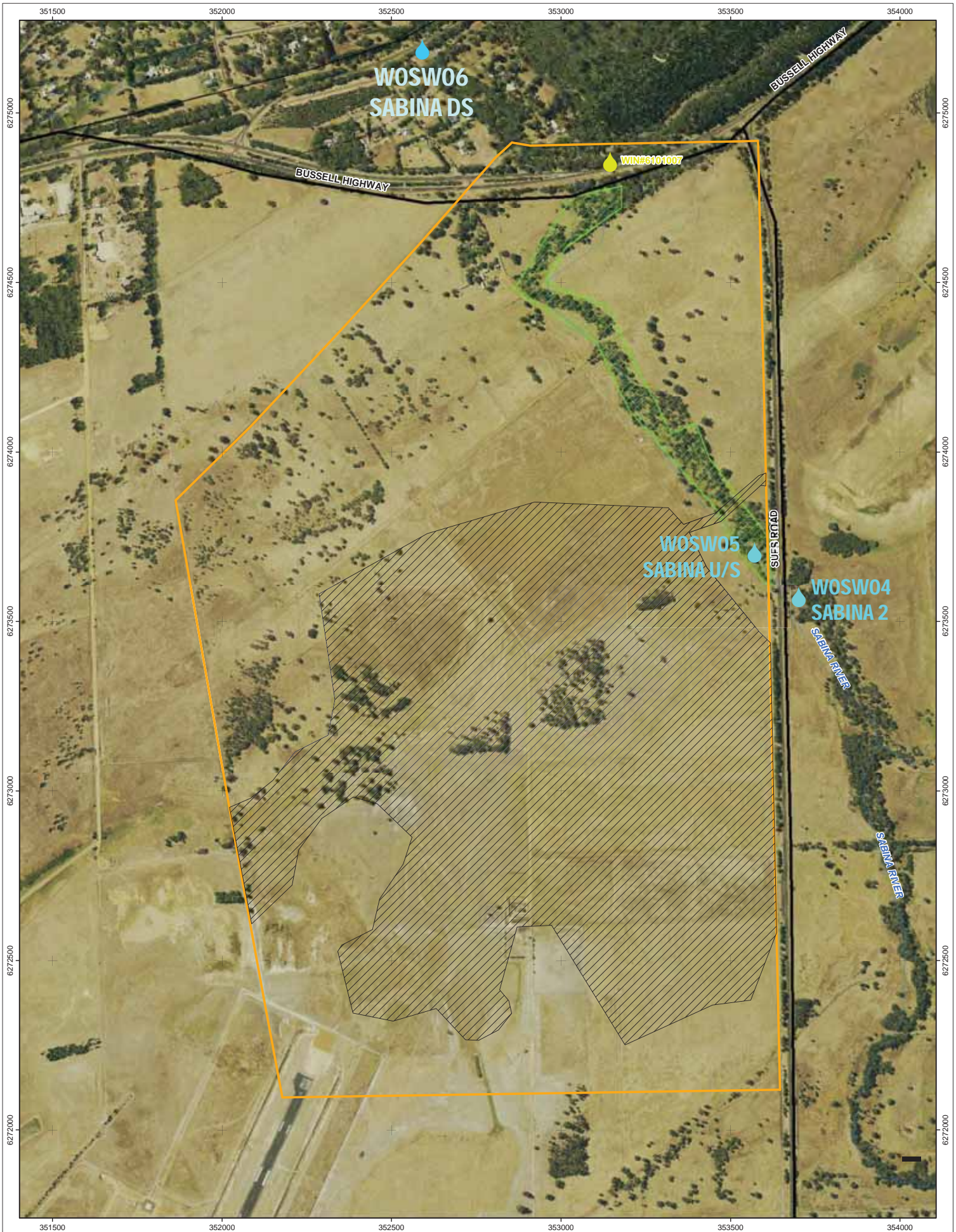
The field survey confirmed the lack of ecological functionality as a result of the historic change in land use to agriculture, and considered the major attribute of the wetlands was their value for supporting summer feed as they retain moisture in the paddocks.



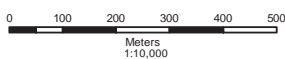
Figure 7: Sabina River foreshore condition, adjacent to Proposal site



Figure 8: Sabina River revegetation works on Lot 3819, near Bussell Highway, carried out by GeoCatch in early 2013



WONNERUP SOUTH
Wonnerup South Project
Surface Water Feature
and Monitoring Locations
Figure 9



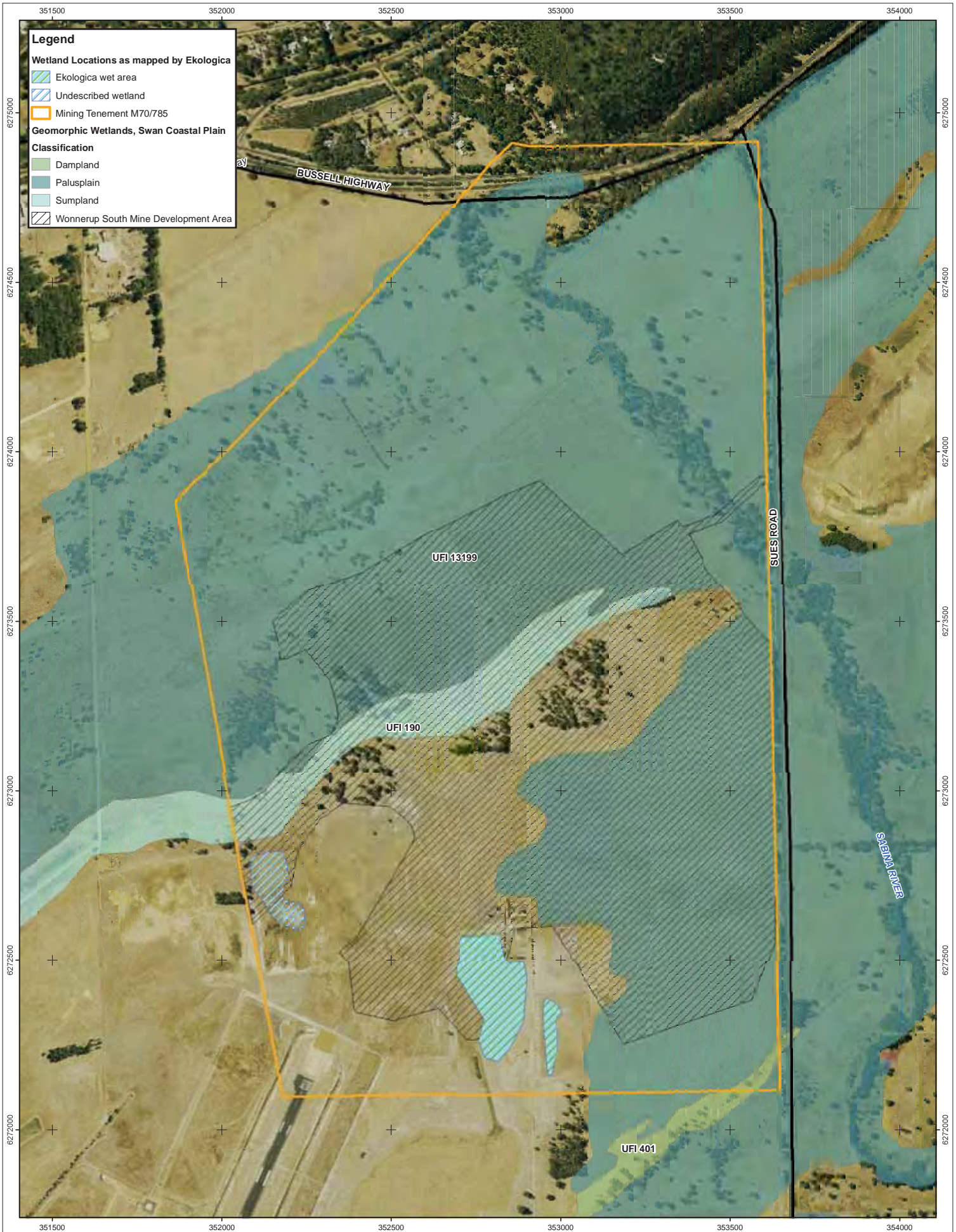
Datum: GDA94 Projection: MGA Zone 50



ennovate environmental consulting		Date:	19/09/2013
Sheet Size:	A3	Status:	FINAL
Drawn by GSM	Requested by ND	Internal Reference Fig7_SurfWater	

Legend

- CS Monitoring Site
- DoW Monitoring Site
- Wonnerup South Mine Development Area
- Sabina River Reserve (R27534)
- Mining Tenement M70/785



3.8 Vegetation and flora

The Proposal is located within the southwest margin of the Swan Coastal Plain and within the Swan Coastal Plain Bioregion (SWA), which is classified under the Interim Biogeographical Regionalisation for Australia. The SWA bioregion is a low lying coastal plain mainly covered with Woodlands. It is dominated by Banksia or Tuart on sandy soils, *Casuarina obesa* on outwash plains, and *Melaleuca raphiophylla* in swampy areas (Harewood 2009).

3.8.1 Survey effort

In 2012, Ekologica Pty Ltd (Ekologica) was commissioned by Cristal to survey and describe the flora and vegetation values of native remnants occurring in and around the Proposed development area. Remnant native vegetation and several wetland areas were surveyed on 27th October 2012. The Ekologica (2012) report is appended in Attachment 4.

The report included a review of previous flora and vegetation surveys of native vegetation remnants completed by Onshore in 2006 (12th April & 4th May) for the combined Wonnerup and Wonnerup South project areas.

3.8.2 Regional vegetation communities

Ekologica (2012) identified 40 species of flora within the Proposal site, of which 30 were introduced species. Species representation was highest amongst the Poaceae (11 species) and Myrtaceae (7 species).

At a site-level of classification, four remnant native plant communities were recognised (Table 4, Figure 11 and Figure 12), all of which consisted of an overstorey of native trees and an understorey of introduced species (pasture species and agricultural weeds). Although the overstorey species and geography of one of the communities (Community B - *Corymbia calophylla* and *Eucalyptus marginata* woodland) are similar to those described for the threatened ecological community (TEC) “*Corymbia calophylla* woodlands on heavy soils of the southern Swan Coastal Plain” (SCP01b), the absence of native understorey taxa and structure make it an unlikely and unsuitable representation of the TEC.

Table 4: Native remnant vegetation associations in the Proposal site

Community	Description
A	<i>Eucalyptus rudis</i> and <i>Agonis flexuosa</i> woodland over grassland/herbland of introduced taxa including * <i>Pennisetum clandestinum</i>
B	<i>Corymbia calophylla</i> and <i>Eucalyptus marginata</i> woodland over <i>Agonis flexuosa</i> , <i>Nuytsia floribunda</i> low woodland over grassland/herbland of * <i>Lolium rigidum</i> , * <i>Hordeum leporinum</i> , * <i>Arctotheca calendula</i> and other introduced species
C	<i>Melaleuca raphiophylla</i> low woodland over grassland/herbland of * <i>Lolium rigidum</i> , * <i>Hordeum leporinum</i> , * <i>Arctotheca calendula</i> and other introduced species
D	<i>Melaleuca raphiophylla</i> low forest over * <i>Zantedeschia aethiopica</i> and * <i>Rumex pulcher</i> herbland

*Introduced species

Due to their small size (< 2 ha) and ongoing grazing, all of the community remnants lack a native understorey component and there was no regeneration of the native overstorey species. All were assessed as ‘completely degraded’ (rating 6) using the definition of Keighery (1994).

Some of the native remnants occur on the Abba Plains soil-landscape system, of which only 5% of the pre-European extent remains uncleared and none is contained in secure reserves (Molloy *et al* 2007, in Ekologica 2012). However, because of the absence of native understorey species and absence of regeneration by the native overstorey species, Ekologica (2012) assessed the remnants as having little or no conservation value as representatives of Abba Plains vegetation.

3.8.3 Conservation significant vegetation and flora

Ekologica (2012) confirmed the observations of Onshore (2006) that no plant taxa gazetted as Declared Rare Flora pursuant to subsection (2) of section 23F of the Western Australian *Wildlife Conservation Act 1950* (WAWC Act) or listed as Endangered under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) were known to be located in the Proposal site. Additionally, no Priority Flora as defined by the (then) Department of Environment and Conservation (DEC 2008, in Ekologica 2012) were located within the site.

3.8.4 Introduced species

The Ekologica (2012) review identified 30 introduced species within the Proposal site. A variety of introduced weeds and grasses had colonised the open infertile sandy soils, with arum lilies well established in high moisture shaded environments.

Two of the introduced weed taxa are listed as Declared Weeds under the *Agriculture and Related Resources Protection Act, 1976* (ARRP Act):

- *Solanum linnaeanum* (Apple of Sodom)
- *Zantedeschia aethiopica* (Arum Lily).

3.9 Fauna

3.9.1 Survey effort

A number of fauna assessments of the Proposal site have been conducted since 2006, namely:

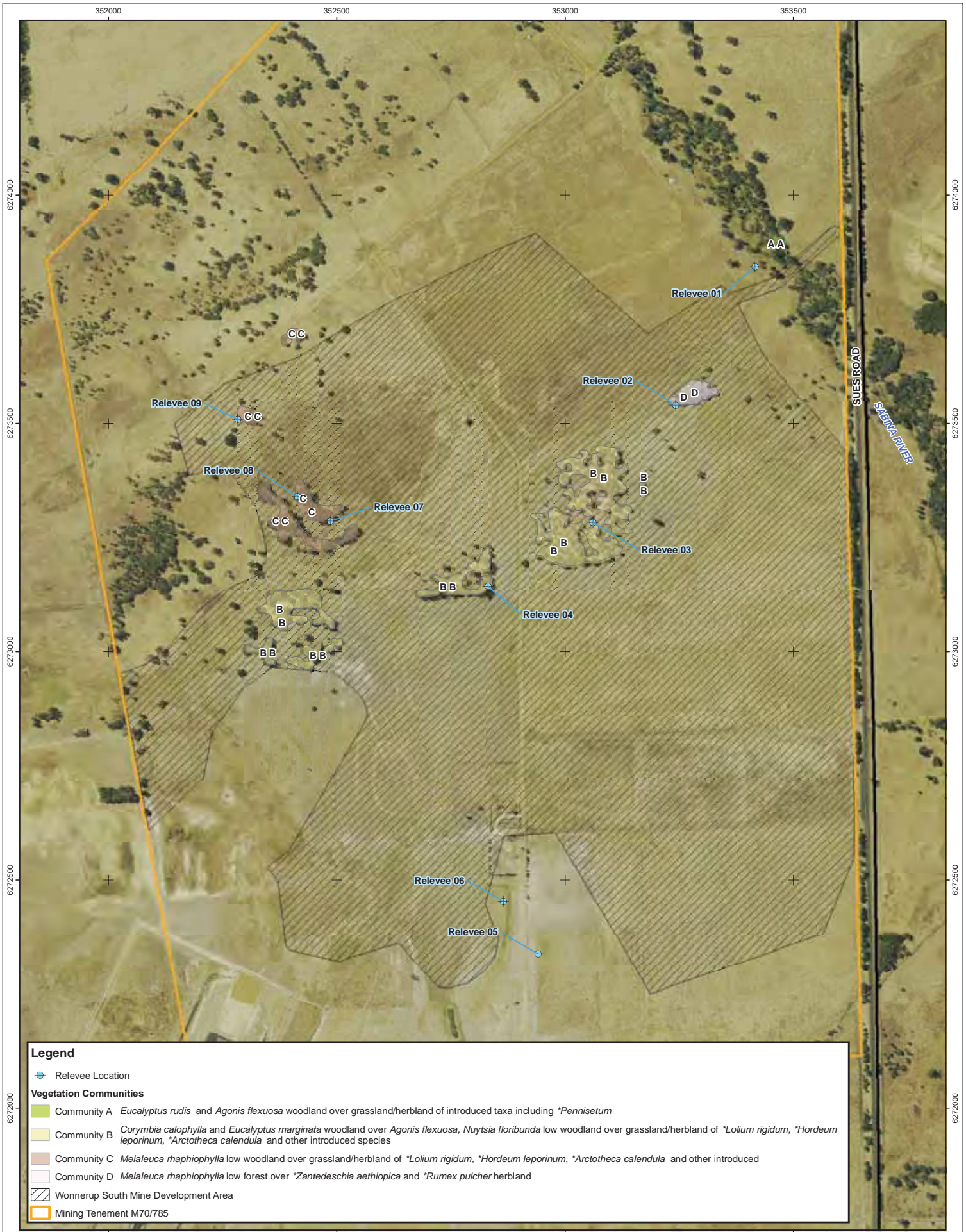
- a Level 1 (desktop and site reconnaissance, including night-time surveys) fauna assessment of the Wonnerup and Wonnerup South project areas was conducted by Greg Harewood (consulting zoologist) over three months in 2006, specifically targeting Western Ringtail Possum (WRP) (Harewood 2006) and followed up in 2009 (Harewood 2009, Wonnerup only)
- a Level 1 assessment of the Proposal area and surrounding areas as part of the environmental planning process for the proposed expansion of the Busselton Regional Airport (BRA), was conducted in 2011 for the City of Busselton (Green Iguana 2011)
- the on-going monitoring of WRP and common Brushtail Possum along the Sabina and Abba Rivers by Cristal as part of its WRP relocation commitments associated with the Wonnerup mine
- a follow-up site assessment (including night-time surveys) of the Proposal site for WRP and black cockatoo⁶ utilisation and habitat values (Attachment 6).

3.9.2 Conservation significant fauna

A review of the EPBC Act Threatened Fauna list, the DEC Threatened Fauna Database and Priority List and scientific publications identified 17 specially protected, priority or migratory fauna species of conservation significance as potentially occurring in the general area of the Proposal.

As the majority of the Proposal site has been cleared of native vegetation and remnant patches are highly degraded, Harewood (2006) considered that the diversity of fauna had been reduced significantly from that which would have originally been present in the area prior to its development and use as a farm. However, the site still hosts a range of fauna species, some of which are of special conservation significance, in particular the WRP.

⁶ Note that for the purposes of his report, Harewood uses the term 'black cockatoo' in reference to Baudin's black cockatoo *Calyptorhynchus baudinii*, Carnaby's black cockatoo *Calyptorhynchus latirostris* and the forest red-tailed black cockatoo *Calyptorhynchus banksii naso*.



Legend

⊕ Revee Location

Vegetation Communities

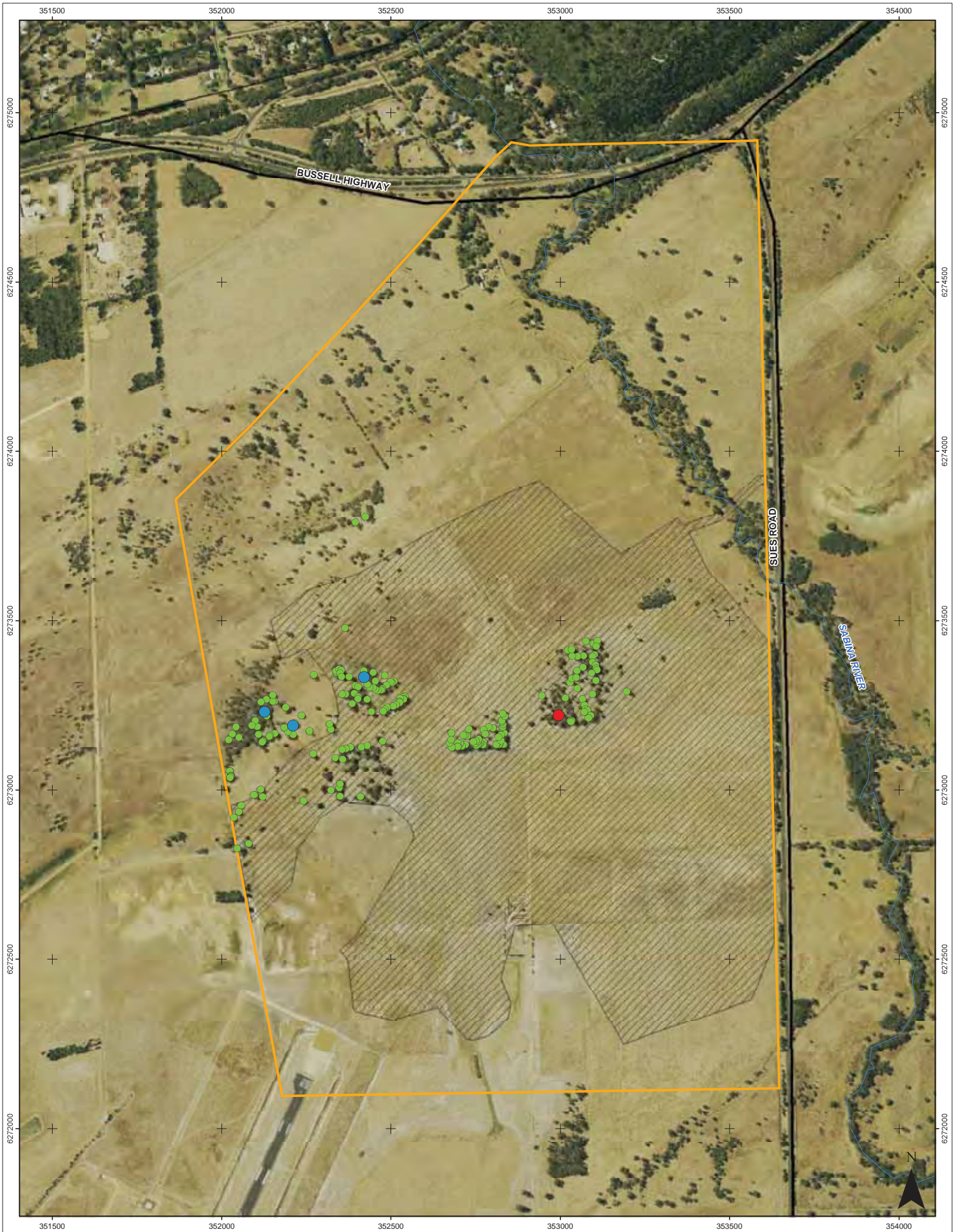
- Community A *Eucalyptus rudis* and *Agonis flexuosa* woodland over grassland/herbland of introduced taxa including **Pennisetum*
- Community B *Corymbia calophylla* and *Eucalyptus marginata* woodland over *Agonis flexuosa*, *Nuytsia floribunda* low woodland over grassland/herbland of **Lolium rigidum*, **Hordeum leporinum*, **Arctotheca calendula* and other introduced species
- Community C *Melaleuca raphiophylla* low woodland over grassland/herbland of **Lolium rigidum*, **Hordeum leporinum*, **Arctotheca calendula* and other introduced
- Community D *Melaleuca raphiophylla* low forest over **Zantedeschia aethiopicum* and **Rumex pulcher* herbland
- Wonnerup South Mine Development Area
- Mining Tenement M70/785

Figure 11



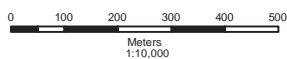
Figure 12: Photographs of the four vegetation communities mapped by Ekologia (2012)

Clockwise from top left: Community A *E. rudis*/A *flexuosa* along river; Community B *C. calophylla*/E *marginata* woodland; Community C and D are both variations of *M. rhamniphylla* woodland.



WONNERUP SOUTH
Fauna field survey results
(Harewood 2013)

Figure 13



Datum: GDA94 Projection: MGA Zone 50

Legend

- Mining Tenement M70/785
- Wonnerup South Mine Development Area
- Sabina Vale Habitat Trees

Fauna Survey

- Brush Tail Possum
- Western Ringtail Possum

A total of 45 fauna species were observed (or positively identified from foraging evidence, scats, tracks, skeletons or calls) within the area during the 2006 assessment. Two vertebrate fauna species of conservation significance were positively identified during the 2006 assessment as utilising the Wonnerup or Wonnerup South sites, these being (Harewood 2006):

- Baudin's Black-Cockatoo *Calyptorhynchus baudinii* – S1 (WAWC Act), Vulnerable (EPBC Act). Observed foraging on site during survey period. Other foraging evidence observed in areas of Marri and Banksia. Most likely a frequent visitor to forage or roost. Small number of hollows potentially suitable for nesting but the probability they have or would be used for this purpose is very low.
- Western Ringtail Possum *Pseudocheirus occidentalis* – S1 (WAWC Act), Vulnerable (EPBC Act). Present in low numbers within remnant vegetation located in the study area.

A 2009 survey undertaken by Harewood at the adjacent Wonnerup site updated the list of observed fauna species from 45 to 53 (Harewood 2009). The 2009 survey also identified an additional two vertebrate fauna species of conservation significance as utilising the Wonnerup site, these being:

- Carnaby's Black-Cockatoo *Calyptorhynchus latirostris* – S1 (WAWC Act), Endangered (EPBC Act). Potentially an infrequent visitor to forage (Marri, Banksia and Jarrah) or roost. Foraging evidence observed (chewed Marri). Small number of hollows potentially suitable for nesting but the probability they have or would be used for this purpose is very low.
- Rainbow Bee-eater *Merops ornatus* – Migratory (EPBC Act). Common seasonal visitor to southwest. Observed during survey period foraging and roosting on site.

Fauna species that were not sighted during the 2006 and 2009 assessments, but which Harewood (2009) considered may utilise the Wonnerup or Wonnerup South sites include:

- Forest Red-tailed Cockatoo *Calyptorhynchus banksii naso* – S1 (WAWC Act), Vulnerable (EPBC Act)
- Great Egret *Ardea alba* – Migratory (EPBC Act)
- Cattle Egret *Ardea ibis* – Migratory (EPBC Act)
- Fork-tailed Swift *Apus pacificus* – Migratory (EPBC Act)
- Barking Owl *Ninox connivens connivens* – P2 (DEC Priority Species)
- Masked Owl *Tyto novaehollandiae* – P3 (DEC Priority Species)
- Peregrine Falcon *Falco peregrinus* – S4 (WAWC Act)
- Southern Brush-tailed *Phascogale Phascogale tapoatafa* spp – S1 (WAWC Act)
- Western False Pipistrelle *Falsistrellus mackenziei* – P4 (DEC Priority Species)
- Water Rat *Hydromys chrysogaster* – P4 (DEC Priority Species).

The 2013 survey re-confirmed the finding of the 2006 assessment that the Proposal site is used by WRPs as habitat (Figure 13). The level of utilisation at the time of the 2013 survey was lower than in 2006 (one individual in April 2013 compared to six June 2006) although results from different seasons can be difficult to compare.

The Harewood (2013) report included a black cockatoo habitat assessment that found the Proposal site to contain 195 trees that fit the DSEWPAC classification of "potential black cockatoo breeding habitat" (DBH > 50cm). Only one of these trees was observed to contain a hollow that, based on size and orientation, appeared suitable for a black cockatoo to enter.

Harewood (2013) assessed the potential value of the five different fauna habitats to WRP and black cockatoo:

- Cleared Pasture: little or no value as habitat for WRPs and black cockatoos.
- Flooded Gum – Marri – Peppermint – Melaleuca Woodland: Some midstorey habitat suitable for WRPs, although very limited in number and extent. Some value as black cockatoo habitat given presence of Marri trees.
- Marri Open Woodland: Little value as WRP habitat. Some value as black cockatoo habitat given presence of Marri trees.

- Peppermint Open Forest: Potential WRP habitat although quality is relatively poor. Some value as black cockatoo habitat given presence of Marri and Jarrah trees.
- Melaleuca Low Closed Forest: Low value for WRP but some value to black cockatoo given presence of a small number of Marri trees.

3.9.3 Introduced species

The desktop survey undertaken for the 2006 fauna assessment identified that two introduced bird and seven introduced mammal species could potentially be found in the broader Wonnerup area. During the 2006 fieldwork two introduced birds and five introduced mammal species were observed (Harewood 2006):

- *Streptopelia senegalensis* Laughing Turtle-Dove
- *Dacelo novaeguineae* Laughing Kookaburra
- *Rattus rattus* Black Rat
- *Vulpes vulpes* Red Fox
- *Felis catus* Cat
- *Bos taurus* European Cattle (as stock)
- *Oryctolagus cuniculus* Rabbit.

The species expected but not observed were the House Mouse (*Mus musculus*) and the Brown Rat (*Rattus norvegicus*).

3.10 Aboriginal heritage

3.10.1 Survey effort

Ethnoscience was commissioned by Cristal to conduct an Aboriginal heritage assessment of the Proposal site (Ethnoscience 2013). Ethnoscience undertook the ethnographic survey and commissioned Thomson Cultural Heritage Management to undertake an archaeological survey (THCM 2013). A previous archaeological survey had been conducted for the site by McDonald, Hales and Associates Pty Ltd (MHA) on behalf of RGC Mineral Sands in 1998 (MHA 1998).

The Ethnoscience ethnographic survey comprised:

- Desktop research
- Preliminary consultation with the (now) Department of Aboriginal Affairs (DAA) and the South West Aboriginal Land and Sea Council (SWALSC) and the Aboriginal community, and selection of the Aboriginal consultants
- Interviews and site inspections with nominated representatives of the South West Boorajarrah and the Harris Family Native Title Claims.

Key findings

The Proposal site contains three Registered Aboriginal Sites (Figure 14):

- the Sabina River (DAA Site ID 17353)
- the 'Heritage Place' Sabina River Camp Ground (DAA Site ID 17350)
- a former Aboriginal mission (DAA Site ID 17355 Uligugillup Mission)

The 1998 ethnographic study by MHA indicated that the mission may have been located in the area (MHA 1998), but the location and the existence of the mission has been the subject of uncertainty. The Ethnoscience report concluded that, due to the absence of any archaeological, historical or firm ethnographic evidence, the Uligugillup Mission did/does not actually exist and certainly not within the boundary depicted by the DAA's Aboriginal Heritage Inquiry System (AHIS). Instead the report identifies that the name may be an alternative reference to Waddidup Mission/Mulgarnup Mission (DAA Site ID 4401), the remains of which are located several hundred metres to the southeast of the Proposal site (Figure 14).

The archaeological survey found no archaeological sites and only one isolated stone artifact, which was located in a highly disturbed context just outside the survey area boundary. The land is considered to have extremely low archaeological potential (Ethnoscience 2013).

3.11 Surrounding land use

3.11.1 Busselton Regional Airport

The BRA is located on an adjoining property and is currently undergoing a program of expansion. Included in the program are plans to extend the airport runway and buffer zone a considerable distance (approximately 900 m) into the Proposal site (Figure 3).

Cristal has established an ongoing working relationship with the City of Busselton in relation to the latter's plans for that section of the city, including other outline projects such as the Busselton Outer Bypass (see below) and the Yalyalup Industrial Area (Figure 3).

3.11.2 Regional roads

According to the traffic flow data, the nearby Bussell Highway supports an estimated 8700 vehicles passing each way daily, 12% of which are classified as heavy vehicles (Main Roads 2013a). Approximately 400 vehicles use Sues Rd daily, 25% of which are heavy vehicles (Main Roads WA 2013a).

Main Roads (2013b) is continuing its planning study to select a preferred alignment for the future Busselton Outer Bypass (BOB) between Sues Road and Bussell Highway, Vasse Newtown. The proposed BOB was initially identified in the Leeuwin Naturaliste Region Plan (SPC 1987), and is included in the Busselton Urban Growth Strategy (1999).

3.12 Near neighbours

Residences within 2 km of the boundary of the tenement (M70/785) are shown in Figure 3. As indicated by the figure, there are 38 residences within 1 km of the boundary and numerous residences within 2 km, including the Provence residential estate. Internal buffers between the Proposal development area and the tenement boundary expand the total distance to Provence to 1.5 km.

3.12.1 Consultation

The proposed program for consultation with near neighbours and community interest groups is summarised below:

- newsletters will be sent on a regular (6-monthly) basis to residences surrounding the Wonnerup South tenement, advising them of the Project, its schedule and company contact details for further information or concerns (similar to the mechanism currently in place for the Wonnerup mine site)
- newspaper advertisements associated with the following environmental approvals:
 - EPBC Act referral (likely controlled action)
 - *Rights in Water and Irrigation Act 1914* (dewatering permit)
 - *Environmental Protection Act 1986* (clearing application and works approval)
- site open days.

3.13 Neighbourhood noise

Background noise levels were monitored for a period of three months at two selected locations from 5 December 2012 to 1 March 2013. The detailed logged noise and weather data have been used as the baseline for predictive noise studies required to support a works approval and licence application with the DER.

Two monitoring locations were selected close to existing residences; one close to Bussell Highway, one further away close to the Provence residential estate.

At each monitoring location the noise monitoring equipment was set to continuously record LA₁, LA₁₀ and LA₉₀ noise levels at 15 minute intervals, where:

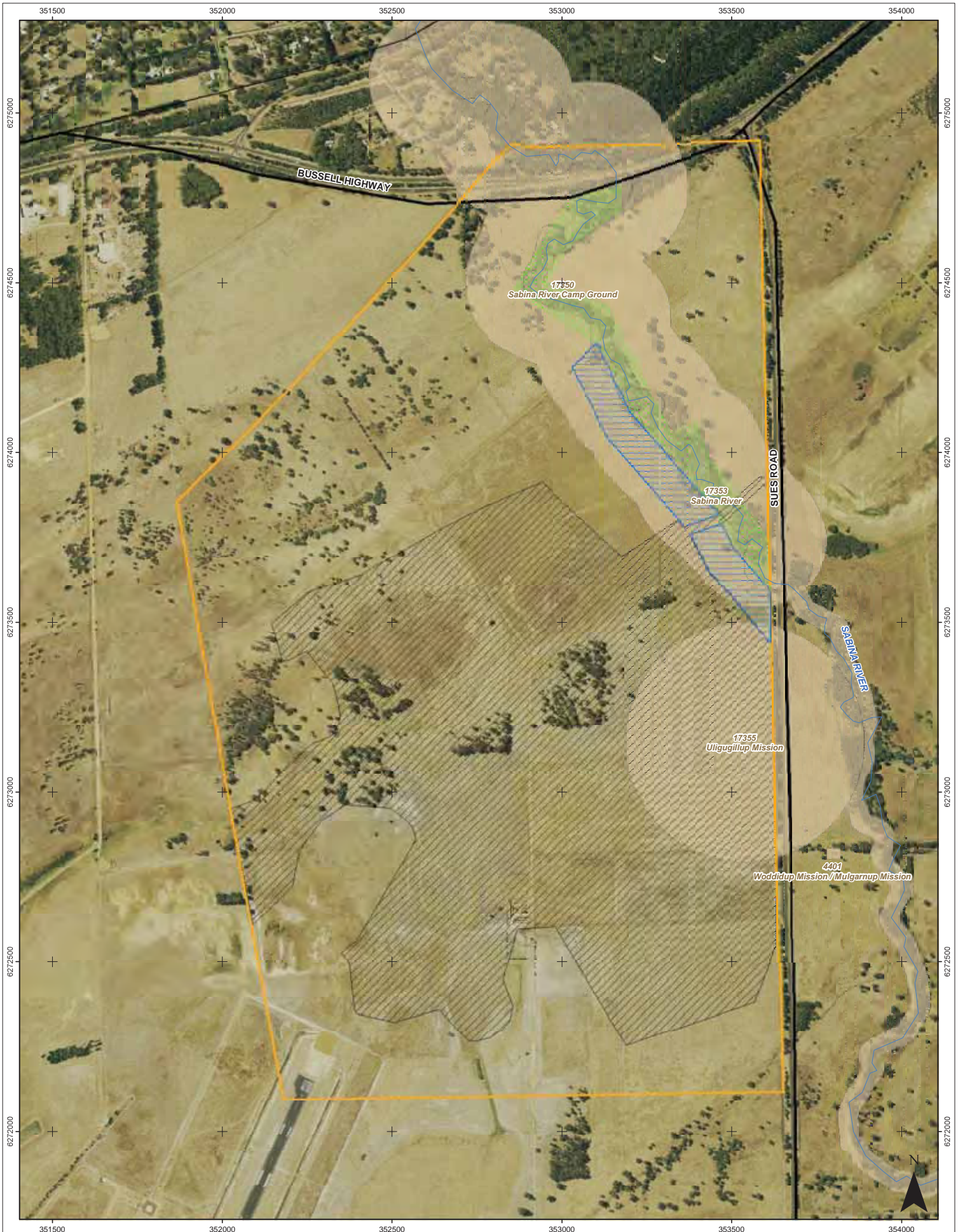
- LA₁ is the noise level exceeded for 1 % of the time;
- LA₁₀ is the noise level exceeded for 10 % of the time; and
- LA₉₀ is the noise level exceeded for 90 % of the time.

“L90” of the LA₉₀ noise levels has been analysed for the day, evening and night-time periods, and is presented in Table 5 below. This data provides an indication of the local ambient noise levels.

Table 5: Background noise at two locations within 1 km of the Wonnerup South site

Logging location	L ₉₀ of measured LA ₉₀ in dB(A)		
	Day	Evening	Night
Logger 1 (near Hwy)	36	27	22
Logger 2 (Provence)	33	33	27

Daytime ambient noise level at location of logger 1 is higher than at logger 2 because of the proximity of the Bussell Highway (approximately 200 m from the monitoring position), but lower for evening and night-time periods. At the location of logger 1 there is a strong diurnal pattern in the recorded noise levels which is typical of road traffic noise. There is also some correlation between underlying background levels (LA₉₀) and wind speed. However, during the day, traffic noise is clearly dominant over wind generated noise. Recordings indicate that the high background noise levels in the evening period at logger 2 are associated with aircraft, birds, insects and frogs, in addition to wind noise.



WONNERUP SOUTH
Wonnerup South Project
Significant cultural features
of the study area
Figure 14



Datum: GDA94 Projection: MGA Zone 50

Legend

- Mining Tenement M70/785
- Wonnerup South Mine Development Area
- Heritage sites
- Sabina River Reserve (R27534)
- Sabina River Buffer

4 Proposal description

4.1 Area of disturbance

The Proposal development area is 190 ha comprising mainly cleared agricultural land. The native vegetation clearing will consist of up to 90 individual paddock trees and five small remnants of less than 1 ha each (4 ha in total). The disturbance areas required for key aspects of the Proposal are provided in Table 6.

Table 6: Area of Disturbance Wonnerup South Proposal M70/785

Disturbance Areas	
Open pits	118 ha (3 orebodies)
Topsoil and overburden stockpiles (including noise bunds)	6 ha topsoil [not including 3 ha ore/noise bunds on orebody and will be mined]
Solar evaporation ponds	25 ha off-path [not including 16 ha built on top of backfilled pits – not considered as additional disturbance]
Water storage dams	0.25 ha collection sumps only (main water storages located at Wonnerup mine)
Plant site and mining infrastructure including office / workshops	0.5 ha (estimated) of office and laydown areas (excluding the use of the Wonnerup mine's facilities) 34 ha of pit standoffs (minimum 15 m), pipeline and powerline corridors, booster pads, standoff (10 m) from off path SEPs, and general areas around stockpiles, roads etc that would be disturbed.
Haul roads	2 ha (approximately 2 km) of main roads to remain for the life of the mine
Access tracks	3 ha (approximately 3 km) of other access tracks/roads off orebody areas
Hardstand areas	0.5 ha (initial contractors laydown on orebody). The project will share the existing hardstand areas at the Wonnerup mine.
Existing disturbances/improvements (estimated)	Farm houses (2), gardens, access tracks, sheds, firebreaks and fences (4 ha) Busselton Regional Airport (6 ha) Old sand quarry adjacent to the airport (4 ha)
Undisturbed	207 ha
Total disturbance area	190 ha
Total tenement area	411 ha

4.2 Site development

4.2.1 Preconstruction

Initial preconstruction activities will be undertaken to provide access and services to the site to allow for the preparation of the site for mining, including:

- creating a site accessway from Sues Rd, directly opposite the Wonnerup mine entrance to minimise traffic interference
- installing services (pipes and power) under Sues Rd, through a Miscellaneous Lease (L70/159), connecting to the Wonnerup mine (not part of this Mining Proposal, pending landowner authorisation)
- constructing a crossing and services corridor over the Sabina River

- installing stormwater diversion works to direct any stormwater flows around the mine disturbance area
- installing internal drainage to sumps for collection and pumping of stormwater and recovered groundwater to the Wonnerup mine water circuit.

The services corridor between the Proposal and Wonnerup mine will:

- connect the power and water supply of the Wonnerup mine to the Proposal
- host the pipeline transporting heavy mineral slurry from the Proposal to the Wonnerup mine for processing
- host the pipeline for transporting the tailings from the processing of the ore back to the Proposal site for pit deposition.

The Sabina River crossing, which is the central feature of the services corridor, will need to provide a span of approximately 15 m in length and up to 12 m in width and would likely be a culvert or galvanised arch bridge, consisting of one or more concrete round pipes (or a single archway) or rectangular box culverts. The exact specifications and final design are yet to be established and would be provided by a suitable Civil Engineering Consultant. Regardless of the final design, important attributes to minimise flooding and erosion of the river banks will be included, such as:

- having adequate capacity for relatively extreme floods (1 in 100 year as target – this means the structure can be considerably smaller than one on a main road such as Sues Rd or Bussell Highway)
- rip-rap or concrete aprons to prevent bank scour
- optimum set-back from the bank to minimise flow constriction
- integrated and stabilised drainage to minimise sediment entering the river.

The design parameters will be finalised in consultation with DoW.

4.2.2 Construction phase

Vegetation clearing, topsoil stripping and stockpiling, and selected ore stripping for noise attenuation bunds are scheduled to commence in mid to late 2016. These activities will prepare the areas to be mined and those areas to be used for out-of-pit SEP placement (Figure 2).

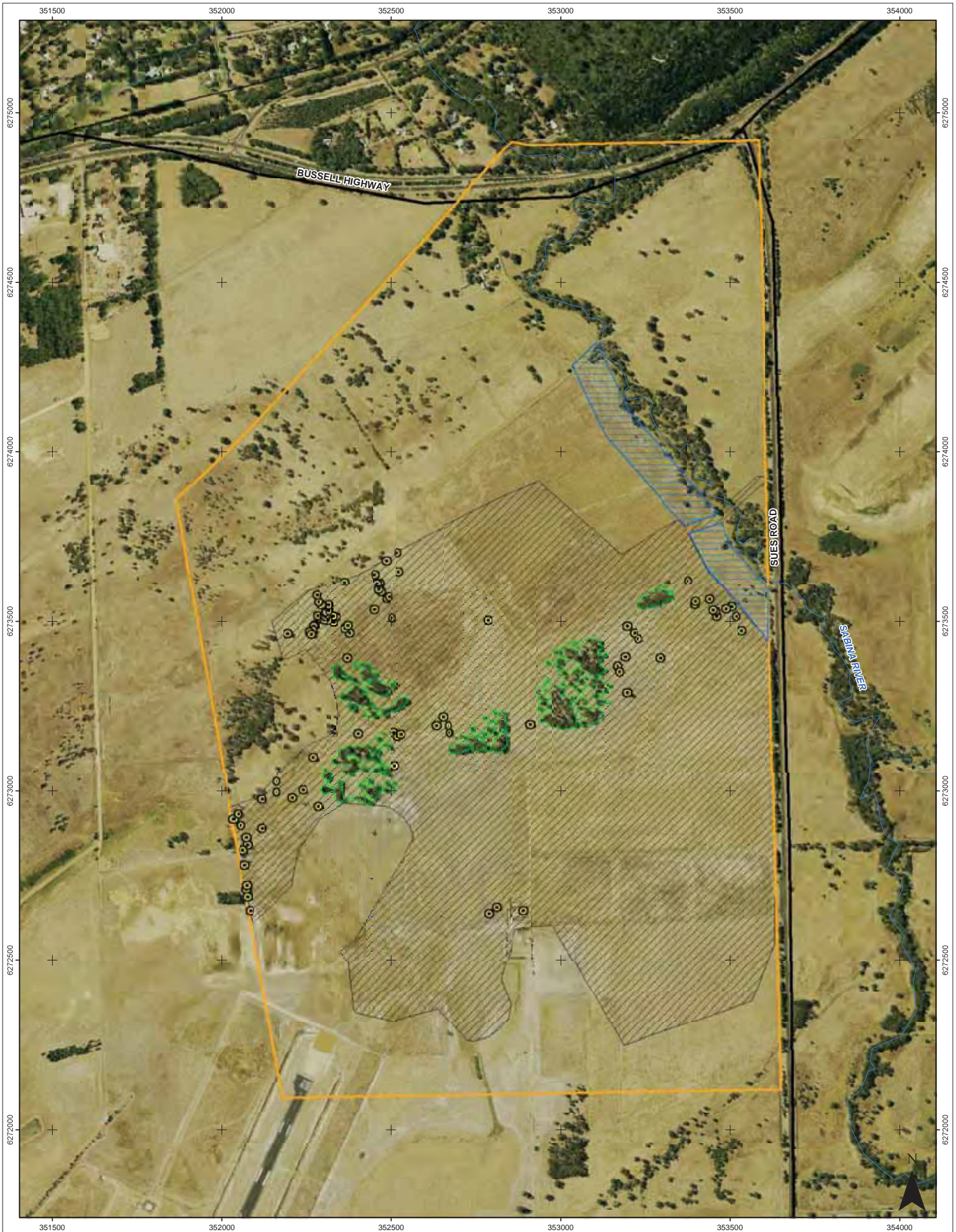
The construction activities will be restricted to day-time operations only (7 am – 7 pm), Monday to Saturday. The construction activities are expected to utilise the following equipment, as a maximum:

- 10 scrapers
- 2 dozers
- 2 front end loaders (FELs)
- 2 excavators
- 1 watercart
- 1 grader
- 4 diesel pumps and 1 electric.

Topsoil will be stripped using scrapers to a maximum depth of 200 mm. Material posing a risk of excessive dust generation (e.g. under dry conditions) will be wetted down prior to stripping.

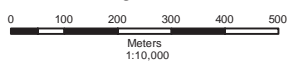
Ore and topsoil stockpiles will be typically located around the perimeter of operations and mine pits to provide a noise and visual barrier. The ore to be relocated for noise bund construction is expected to be sourced from the northern satellite deposit (to a depth of 2-3 m). The areas excavated in the construction of the noise bunds will also provide initial voids for tailing at the start of processing.

Based on the groundwater modelling studies (see section 3.7.2), the ore relocation pit will not intercept the water table, so no dewatering will be undertaken during this stage.



WONNERUP SOUTH
Proposed native vegetation
clearing requirements

Figure 15



Datum: GDA94 Projection: MGA Zone 50

- Legend**
- Individual trees to be removed
 - Vegetation remnants to be removed
 - Mining Tenement M70/785
 - Wonerup South Mine Development Area
 - Sabina River Buffer

4.3 Mining operations

Typically, mining operations will involve stripping and screening or stockpiling of ore. The blending of different ore grades by dozer or FEL might be required prior to screening (predigestion).

The FELs will load in-situ or stockpiled ore into rotary wet screens to reject oversize (> 4 mm) material, thereby separating large rocks, roots and gravel from the ore. The screened slurry will be pumped to the wet processing plant at the Wonnerup mine.

Mining at Wonnerup South is expected to be a 24 hours per day 7 days per week operation.

4.3.1 Mine dewatering

The low-yielding nature of the formation hosting the ore negates any requirement to actively dewater the site prior to excavation commencing. Instead, the mine pit will be continuously excavated using conventional dry mining techniques.

Groundwater which passively enters the pit void will be collected in sumps and drains. The collected water will be used to create the ore slurry for transportation to the Wonnerup mine or pumped to the Wonnerup mine directly. At the Wonnerup mine, the water will be managed as part of the existing process water circuit, where, if necessary, it can be treated prior to being added to the water supply dam for storage and eventual re-use within the mine water circuit. Surplus water that meets environmental quality criteria will be discharged through the Wonnerup mine's licenced system (Figure 9)

4.3.2 Processing

Processing will be undertaken at the existing wet concentrator at the Wonnerup mine where the heavy mineral concentration process will produce the HMC. Mining activities at the Wonnerup mine will largely cease for the duration of the Proposal, while the facilities used for wet processing, product haulage, plant and site maintenance, and water treatment will continue to operate. The concentrator process at the Wonnerup mine is a wet slurry process that includes several stages of gravity separation to concentrate the high-value heavy minerals. The majority of silica minerals, low grade titanium minerals, and trash minerals will be rejected to tailings from the wet concentrator plant. A high grade mineral concentrate will be produced containing the valuable ilmenite, leucoxene, zircon and titanium minerals.

Throughput and production from the plant will vary with the nature and grade of the deposit in different areas. The HMC will be de-watered and stockpiled at the existing stockpile site at the Wonnerup mine site prior to being trucked to the MSP at North Shore, Bunbury.

4.3.3 Waste handling

The main waste products will be sand tails, clay fines and reject (oversize) materials.

Sand tailings

Sand tails produced in the wet separation plant following removal of HMC will be returned to the mining void as part of the rehabilitation process. In addition, mill tailings from the dry separation plant at North Shore will be periodically returned to the mining void. This material will typically consist of silica sand that was unable to be removed from the HMC stream during initial processing at the wet separation plant, with the remainder consisting of small amounts of HMC that cannot be separated into saleable mineral, fly-ash, collected dust, oversize material and fines. Mill tailings from previous mine sites have typically contained less than 100 parts per million (ppm) of radioactive elements.

Fines

Water from the wet screening and separation processes will be treated for re-use. This will involve using a gravity thickener tank to settle clays and other fine particles (fines) from the process water and is facilitated by the addition of non-toxic flocculants and coagulants to encourage settling.

Clean water from the top of the thickener tank will be pumped to the process water pond for storage. A thickened slurry of settled fines will be pumped back to the Wonnerup South SEPs for drying. Clean water will be decanted from the SEPs and recycled for reuse in the mining process. Once the fines have dried to a manageable state, they will be incorporated into tails during landform redevelopment.

Oversize rejects

Any oversize material in the ore screened from the rotary trommels (e.g. large rocks, roots and gravel) will be used as road base or pads, if suitable, or otherwise returned to the mining pit.

4.3.4 Water requirements

A site water balance has been completed and indicates an annual average project demand of 300 megalitres (ML) mostly for dust suppression and from losses during wet screening and tails pumping. Water use at the Wonnerup wet plant to treat the recovered ore will continue at current rates under the relevant licence for that site.

Water demand will be largely met from the Wonnerup production bore which is screened in the Yarragadee Formation and licensed by DoW. Additional sources include inflows to the pit and site stormwater. Water use is kept to a minimum by recirculating process water and treating it to maintain a quality suitable for re-use.

4.4 Support facilities

4.4.1 Wonnerup operation

The facilities at the existing Wonnerup mine that will be used by the Proposal is covered in section 2.3.

4.4.2 Public road use

Heavy vehicles and equipment from the Wonnerup operation will be transferred between the two sites at start-up and at closure. There will also be an ongoing but limited requirement for staff to move between the Wonnerup and Wonnerup South minesites, crossing over Sues Road in light vehicles.

Haulage of HMC from the Wonnerup mine site (including from HMC sourced from the Proposal) to the North Shore Mineral Separation Plant (MSP) at Bunbury would continue under existing approvals and management plans.

4.4.3 Mineral Separation Plant

The Cristal North Shore MSP is located in Bunbury close to the port used for shipment of bulk mineral products. The MSP is a conventional mineral sand separation process consisting of a variety of electrostatic, magnetic and wet gravity separation equipment. Finished products would be sold from the MSP to both local and international customers.

4.5 Workforce

The workforce for the Proposal will be made up predominantly of staff and contractors currently operating the Wonnerup mine (approximately 30 staff plus contractors). The workforce typically lives locally, within the greater Bunbury and Busselton areas.

Additional contractors will be required during the construction phase. These services are usually sourced locally, through a tender process.

4.6 Compliance with legislation and other approvals

4.6.1 Tenement conditions

The Proposal is located wholly within M70/785, which is 100% held by Cable Sands. No aspects of this Mining Proposal are contrary to the tenement conditions.

4.6.2 Other approvals

Environmental approvals required by Cristal to develop and operate the Proposal are listed in Table 7.

Table 7: Environmental approvals for the Proposal (not exhaustive)

Aspect	Legislative requirement	Process and progress
Mineral sands mining; Mine dewatering	<i>Environmental Protection Act 1986; Environmental Protection Regulations 1987 Mining Act 1978</i>	Works Approval and licence amendment, to be submitted Mining Proposal (this document).
Dewatering	<i>Rights in Water and Irrigation Act 1914</i>	5C Abstraction application, to be submitted.
Water supply	<i>Rights in Water and Irrigation Act 1914</i>	Groundwater licence issued for Wonnerup (within current allocation).
Noise	<i>Environmental Protection (Noise) Regulations 1997</i>	Works Approval, to be submitted.
Surface water discharge	<i>Environmental Protection Act 1986</i>	Works Approval and licence application, to be submitted
Impacts to Ramsar (Vasse-Wonnerup) wetland	<i>Environment Protection and Biodiversity Conservation Act 1999</i>	EPBC Referral, to be submitted (Agency consultation undertaken).
Vegetation clearing and wetlands, including impacts to fauna	<i>Environmental Protection (Clearing of Native Vegetation) Regulations 2004</i> <i>Environment Protection and Biodiversity Conservation Act 1999</i>	Native Vegetation Clearing Permit application, to be submitted. EPBC Referral, to be submitted (Agency consultation undertaken).
Crossing and service corridor construction (Sabina River)	<i>Aboriginal Heritage Act 1972</i>	S18 Application, to be submitted.
Radiation	<i>Radiation Safety Act 1975</i>	Radiation Management Plan

5 Environmental impacts and management

5.1 Overview

A summary of the potential impacts associated with the Proposal along with proposed management commitments and timelines for implementation is provided in the front of this document. The potential impacts and management measures are discussed in further detail in the remainder of Section 5.

5.2 Approach to environmental impact assessment

The environmental impact assessment for the Proposal has been broadly based on the impact assessment framework described in Australian Standard AS/NZS ISO14015:2001 *Environmental assessment of sites and organisations*. The framework has been adapted to address the requirements of the DMP Mining Proposal Guidelines (DMP 2006).

Assessment criteria have been developed and used to evaluate the potential impacts of the Proposal. The criteria represent the desired social and environmental outcomes of the mine, as determined by government and industry guidance or as output from consultation with stakeholders.

The impact assessment process has involved the following phases:

- Identifying the values of the receiving environment that require protection.
- Predicting how these values may be impacted by project activities.
- Developing management and mitigation measures to avoid, minimise, control, ameliorate or rehabilitate significant impacts.
- Determining the acceptability of the residual (managed and mitigated) impacts in relation to the assessment criteria.

The assessment has been developed by:

- building upon the environmental investigations undertaken during the approvals for the Wonnerup mine, including:
 - Flora and vegetation survey (Onshore 2006)
 - Groundwater environmental impact assessment (URS 2008)
 - Fauna assessment (Level 1) (Harewood 2009)
 - Baseline water quality study (Coffey 2010)
 - Acid sulfate soil investigation (Coffey 2010)
- Using the knowledge of environmental performance gained from operational and environmental monitoring data at the Wonnerup mine
- Undertaking specific environmental investigations for the Proposal, including:
 - Fauna assessment (Level 1), (Harewood 2006)
 - Vegetation, flora and wetland survey, (Ekologica 2012)
 - Wetlands buffer investigation, (Ecosystem Solutions 2013)
 - Western ringtail possum survey and black cockatoo habitat assessment (Harewood 2013)
 - Acid sulfate soil investigation and management plan (Aurora 2013)
 - Ethnographic survey (Ethnoscience 2013)
 - Noise assessment and modelling (SVT, in prep.)
- Liaison with key regulatory agencies, local landholders and the Busselton City Council.

The impact assessment and management process is an iterative one, with additional management controls or design options being finalised as required to acceptably minimise impacts.

5.3 Environmental management framework

5.3.1 Environmental management system

Cristal has an Environmental Management System (EMS) certified to ISO 14001. Certification was confirmed in July 1997 and was a world first for a titanium minerals company and the first Australian mining company to have mining operations certified to that standard. The core of the EMS is the company's Environmental Policy, which has been approved and signed by the Director of Cristal Mining Australia Limited.

Cristal's EMS has been implemented at the Wonnerup mine and will be extended to this Proposal. The EMS will help implement best practice environmental management at the Proposal site during all phases of the project, including construction, operation, decommissioning and rehabilitation. The EMS is complemented by a certified Quality Management System (AS/NZS ISO 9001), and a certified Safety Management System (OHSAS 18001 and AS 4801).

5.3.2 Responsibilities

The EMS designates the responsibilities of the various staff positions and/or levels, as set out in Table 8.

Table 8: Responsibilities prescribed by the Cristal EMS

Party	Responsibility
Operations Manager	Responsibilities include ensuring that all Cristal activities conform to the Environmental Policy.
SHE Manager	Responsibilities include taking immediate action where necessary on the receipt of communications and/or complaints regarding environmental issues.
Mining Manager	Responsibilities include ensuring that the mine is designed, developed and operated in accordance with company policies, approvals, permits and other undertakings.
Senior Environmental Officer – Operations & Compliance	Responsibilities include ensuring compliance with relevant environmental legislation and regulations, managing the EMS, maintaining documents and records to demonstrate conformance, and identification of non-conformances with the EMS.
All employees	Responsibilities include ensuring that all operations are carried out in accordance with specified procedures and work practices.

5.3.3 Hazard identification

Environmental aspects, which are at risk of being impacted upon by the mining operations, are identified using the procedures set out in SP03 *Identification and Management of Environmental Risks*.

5.3.4 Communication

The EMS contains procedures for managing internal and external communications of environmental matters. Environmental hazards and incidents are reported using an incident report (CD018). All external complaints automatically generate an incident report that is forwarded to and dealt with by the Environment Department.

5.3.5 Community consultation and complaint procedures

Cristal has a commitment, under its Environmental Policy, to involve the community in aspects of impact management.

Community Consultation

Cristal will continue to liaise with residents and other interested stakeholders with the purpose of informing the community about environmental issues, including noise, or to obtain community feedback and attitudes towards its operations and performance.

Complaint Response Procedures

Any environmental complaint will be systematically processed through the Cristal EMS. Responsibility for action lies with the SHE Manager. The Environment Department reports complaints and other non-conformances that are related to environmental approvals or permits to the appropriate government regulator.

5.3.6 Monitoring

In addition to collecting baseline data, monitoring will be undertaken to verify impact predictions, assess the effectiveness of management measures and drive continual improvement. Monitoring will be coordinated by the Senior Environmental Officer and will be conducted in accordance with the appropriate procedures.

5.3.7 Auditing

Cristal routinely conducts internal audits to assess the compliance with, and effectiveness of the various components of its EMS. In addition, the entire EMS is audited externally every year, with a full re-certification audit every three years.

Audit findings are reviewed by the Integrated Management Systems Committee, including the Operations Manager, and acted upon by the Senior Environmental Officer, through the EMS.

5.3.8 Review and reporting

Monitoring results and performance and compliance assessments are reported each year to the relevant government agencies and can be made available to relevant stakeholders on request.

5.4 Relevant factors

The environmental impact assessment for the Proposal has taken into consideration the following relevant factors:

- Vegetation and flora (land clearing)
- Fauna (land clearing)
- Surface water (drainage)
- Groundwater (dewatering and production supply)
- Wetlands
- Acid sulfate soils
- Noise and vibration
- Visual amenity and light
- Dust and other atmospheric emissions
- Hydrocarbon and chemical use
- Radiation
- Waste management.

The following sub-sections assess each of these factors in turn by considering relevant project activities, potential impacts and proposed management.

5.4.1 Assessment against the Native Vegetation Clearing Principles

As identified in section 4.6.2, approval under s51E of the Environmental Protection Act (EP Act) will be required for the proposed clearing and will be the subject of a separate Vegetation Clearing Permit application. Schedule V of the EP Act prescribes ten Clearing Principles that aim to ensure

that all potential impacts resulting from the removal of native vegetation can be assessed in an integrated way.

The assessment of the proposed vegetation clearing against the Clearing Principles is provided in Table 9. The assessment provides a good overview of the potential impacts associated with the Proposal and identifies priority areas for management and/or offsets.

Table 9: Assessment against the Native Vegetation Clearing Principles

Principle	Assessment
A: it comprises a high level of biological diversity	Numerous vegetation surveys assessed the remnant vegetation to be cleared as completely degraded, with understorey and herb strata absent, being replaced by introduced grasses. The suitability as habitat for fauna is correspondingly low and only a small variety of animals have been recorded there.
B: it comprises the whole or a part of, or is necessary for the maintenance of, a significant habitat for fauna indigenous to Western Australia	The utilisation of the remnants by conservation significant fauna such as WRP and black cockatoo increases the ecological value of the remnant. The WRP has a preference for Peppermint (<i>Agonis flexuosa</i>) trees, particularly if close to water and with good connectivity. Black cockatoo species have a reliance of Marri and, to a lesser extent on Jarrah, for forage. Other large eucalypts such as the flooded gum may offer nesting or roosting sites. 195 trees within the study area have DBH greater than 50 cm, but only one tree with a potentially usable hollow was observed.
C: it includes, or is necessary for the continued existence of, rare flora	No threatened (i.e. Declared Rare or Priority) flora have been identified on the site and, owing to the use of the area for agriculture (pasture production and grazing), the potential for additional species to regenerate is minimal.
D: it comprises the whole or a part of, or is necessary for the maintenance of, a threatened ecological community	There are no TEC within the Proposal area.
E: it is significant as a remnant of native vegetation in an area that has been extensively cleared	Due to the absence of native understorey species and overstorey regeneration, as well as their small size, the remnants are considered to have little or no conservation value. The equivalent area of native vegetation will be re-established as part of the Proposal.
F: it is growing in, or in association with, an environment associated with a watercourse or wetland	Assessments of the wetlands and vegetation remnants on the site conducted by qualified botanists and natural resource management (NRM) professionals stated that the wetland areas had very little to no conservation significance. The crossing point for the Sabina River has been selected to avoid or minimise clearing requirements. Native plant species that will or may require removal include <i>Eucalyptus rudis</i> , <i>Agonis flexuosa</i> and <i>Melaleuca viminea</i> (planted). To ensure the Sabina River is protected generally, a 100 m stand-off (buffer) has been incorporated into the mine plan. Vegetation communities C and D are both dominated by Swamp Paperbark <i>Melaleuca raphiophylla</i> , however neither of these communities were growing in association with a wetland and more likely to be an expression of the seasonally waterlogged soils of the area.
G: the clearing of the vegetation is likely to cause appreciable land degradation	The Proposal site is generally flat-lying and has already been substantially cleared for agriculture. Increased water-logging and/or salinisation of soils are not a risk in the area.

Principle	Assessment
H: the clearing of the vegetation is likely to have an impact on the environmental values of any adjacent or nearby conservation area	The closest formal conservation area is the Ludlow National Park, 2 km to the northeast of the Proposal and would not be affected by it. The Sabina River is has been mapped as a Regional Ecological Linkage. The construction of the bridge crossing is unlikely to effect this linkage owing to the presence of the considerably larger Sues Road bridge 250 m upstream.
I: the clearing of the vegetation is likely to cause deterioration in the quality of surface or underground water	Although the operations as a whole have an inherent potential to impact water quality, these are not directly related to vegetation clearing.
J: the clearing of the vegetation is likely to cause, or exacerbate, the incidence or intensity of flooding	The Proposal constitutes a small percentage (less than 0.5%) of the catchment and the area is very flat and low-lying. Stormwater runoff within disturbed areas of the Proposal will be captured and managed as a standard operational requirement. Following mining, the site will be rehabilitated and drainage reinstated

5.4.2 Offsets

An Offsets Management Plan (2012) was prepared as part of the Native Vegetation Clearing Permit application for the Wonnerup mine to address, amongst other things:

- offset locations, objectives and management
- fencing and weed control
- stream-side stabilisation
- infill planting and revegetation to improve black cockatoo and WRP habitat.

It is anticipated that a similar plan will be prepared for the Proposal and suitable areas and revegetation strategies will be presented as part of the Native Vegetation Clearing Permit application for Wonnerup South.

5.5 Vegetation and flora

5.5.1 Key considerations

As described in Section 3 Existing Environment, the key environmental values and functions associated with vegetation and flora within the area of influence of the Proposal are:

- no plant species or communities of conservation significance were identified within the study area
- vegetation remnants have been mapped as four plant community types, however they are in a degraded condition owing to the absence of understorey and prevalence of introduced species
- vegetation remnants and isolated paddock trees provide limited habitat for native fauna, including conservation significant species (see section 5.6)
- the remnants to be cleared are all small in size (less than 1 ha) and are not connected or protected from threatening processes, including grazing.

5.5.2 Relevant activities

The Proposal includes the following activities with potential implications for vegetation and flora:

- clearing during development of vegetation remnants (4 ha) and paddock trees (up to 90) within the Proposal site
- lowering of the superficial water table to below the base of mining (-2 m)
- rehabilitation of cleared native vegetation as part of the Proposal.

5.5.3 Potential impacts

Although the Proposal is set predominantly in cleared agricultural land, the clearing of native vegetation remnants and single trees will be required (Figure 15). The remnants are each less than 1 ha in size and have been assessed as 'completely degraded' owing to the almost total absence of original understorey and prevalence of introduced species. No plant taxa of conservation significance on either state or federal listings were identified during surveys and none are considered to be located within the Proposal site.

The lowering of the superficial water table during mining could affect vegetation that is sensitive to groundwater availability. This potential impact is considered to be unlikely and also small in scale as most of the drawdown is confined to the development area. Contingency responses have been developed in the event that influences are detected (see section 5.8).

The potential introduction and spread of weeds at the Proposal site has been considered and determined to be very low. Thirty introduced plant species have already been identified within the site, including two Declared Weeds under the ARRP Act (see Section 3.9.3).

5.5.4 Proposed management

The following management and mitigation measures will be implemented for vegetation and flora:

- Implement standard procedures that restrict vegetation clearing to approved areas and also to a practical minimum; and maximise retention of rehabilitation resources, such as topsoil, brush and habitat logs.
- Avoid disturbing riparian vegetation within 100 m of the Sabina River (see discussion of river buffer below) and giving preference to degraded stretches for construction of the river crossing.
- Implement a Weed Management Protocol that outlines procedures for identifying, preventing and controlling invasive and Declared weeds.
- Develop a Dewatering Operation Strategy to the satisfaction of DoW that, amongst other things, takes into account risks posed to vegetation due to the lowering of the superficial water table during mining (see section 5.8).
- Rehabilitate remnant native vegetation cleared by project activities using endemic species, in accordance with rehabilitation objectives, completion criteria and procedures that are described in the Wonnerup South Mine Closure Plan (see Section 7).

5.6 Fauna

5.6.1 Key considerations

Three fauna species of conservation significance that are listed under both under the WAWC Act and the EPBC Act have been identified during surveys at the Proposal site (Baudin's Black-Cockatoo, Carnaby's Black-Cockatoo and WRP) (see Section 3.8.3). The Rainbow Bee-eater, which is on the EPBC list as a migratory bird, was also observed. Harewood (2013) considered that an additional ten fauna species of either federal or state conservation significance may utilise the area, although they have not been directly observed.

Evidence was found that Baudin's Black-Cockatoo and Carnaby's Black-Cockatoo were using the site for foraging, but Harewood (2013) considered that the probability that they have used, or would use, the small number of hollows observed on site for roosting was very low. Only one of 195 trees classified as potential black cockatoo breeding habitat was observed to contain a hollow that, based on size and orientation, appeared suitable for a black cockatoo to enter (see Section 3.8.3).

Both Harewood 2006 and 2013 found that the Proposal site is being used by WRP as habitat.

5.6.2 Relevant activities

The Proposal will include the following activities with potential implications for fauna:

- clearing of remnant native vegetation and the habitat it provides, as outlined in Section 5.5
- the use of machinery, equipment and vehicles on site (noise and physical encounters).

5.6.3 Potential impacts

The remnant native vegetation that will be cleared for the Proposal has been classified as completely degraded and its value as diverse and functional fauna habitat is accordingly diminished. The remnants are still utilised by conservation significant fauna (WRP and Black Cockatoo) but are not considered as containing sufficient resources to act as important habitats for these species.

The most important habitat area within the Wonnerup South tenement is the Sabina River and its fringing vegetation, which is a recognised Regional Ecological Linkage (REL, Molloy et al 2009). This habitat will not be affected by the Proposal, with the exception of the crossing and services corridor, which would be constructed at a section of the river with very little if any remnant trees (Figure 2).

5.6.4 Proposed management

The following management and mitigation measures will be implemented for fauna:

- Adopt the management measures for vegetation and flora as outlined in Section 5.5, including native vegetation rehabilitation.
- Develop and implement a Threatened Fauna Management Plan that addresses, amongst other things:
 - habitat clearing and fauna relocation protocols, including pre-clearing surveys and restricting clearing to non-breeding months
 - retention of black cockatoo and WRP habitat where possible
 - training and awareness requirements for staff and contractors
 - neighbourhood feral predator control programs
 - objectives and actions relating to fauna recolonisation for incorporation into the Closure Plan and Offset plan.

5.7 Surface water

5.7.1 Key considerations

As described in Section 3 Existing Environment, the key environmental values and functions associated with surface water within the area of influence of the Proposal are:

- the Sabina River, which discharges into the Ramsar-listed Vasse Wonnerup wetland system
- agricultural drainage to address seasonal inundation in the pre- and post-mining landscape.

5.7.2 Relevant activities

The Proposal includes the following activities with potential implications for surface water:

- land clearing and disturbance
- construction and operation of project infrastructure and facilities, including the Sabina River crossing and services corridor
- lowering of the superficial water table to below the base of mining
- the use of machinery, equipment and vehicles
- the use of hydrocarbons and chemicals
- stormwater and process water collection and management
- landform reinstatement, contouring and rehabilitation.

5.7.3 Potential impacts

Development of the Proposal, including construction of the Sabina River crossing, internal roads and earthworks generally, has the potential to alter stormwater volumes and quality, particularly the movement of sediments. Operations include the refuelling and simple maintenance of the earth-

moving equipment, as well as pumps and pipes, and these have the inherent risks of leaks and spills, which could result in contaminated surface runoff if volumes are sufficient.

There is no requirement to discharge stormwater from the Proposal site into the Sabina River. All affected stormwater and groundwater inflows will be recovered and pumped across to the water management system at the existing Wonnerup mine. All surface drainage from outside of the development area will be diverted into existing agricultural drains to the west and south (Figure 9).

A risk to flows in the Sabina River comes from the requirement to dewater the Proposal site to the base of mining. As discussed in section 3.7.2, this aspect has been studied by URS (Attachment 5), where the potential to lower the groundwater levels under the Sabina by up to 10 cm has been predicted and a precautionary management response developed.

5.7.4 Proposed management

Cristal will prepare and implement a Water Management Plan that will include the following approaches and measures to protect the quality and flow regimes of surrounding surface water systems from the mining proposal:

- continued adoption of relevant controls, as described in the *Water Quality Protection Guidelines for Mining and Mineral Processing* (WA Govt 2000)
- incorporate a 100 m standoff from the Sabina River, as marked from the edge of the river reserve (Figure 9) for all activities apart from the bridge/service corridor
- construct the river crossing and monitor water quality up and down-stream of the works until stabilisation is considered adequate
- install diversion bunds around the mine development area to prevent uncontrolled runoff or discharges from the disturbed areas
- construct internal drains and sumps for the collection (harvesting) of site stormwater, pending transfer to the Wonnerup water circuit for treatment and re-use
- manage the construction and operation of SEP in accordance with established internal procedures
- install and maintain pipelines in accordance with established internal procedures
- safeguard and respond to spills and leaks of hazardous chemicals and hydrocarbons in accordance with established internal procedures and relevant licence conditions (see section 5.13)
- continuation of the approved water management and treatment system at the Wonnerup mine, including the routine monitoring of the quality and quantity of discharges and the chemistry of the Sabina River, up and downstream of the overflow point.

The Water Management Plan will be prepared and implemented to the satisfaction of the relevant authorities, such as the DoW and DSEWPAC.

With regards to the construction of the Sabina River service crossing, hazards to water quality and stream function and form will be managed by:

- undertaking construction during warmer months when flows have subsided and the chance of heavy rainfall is minimal
- keeping the disturbance to a practical minimum
- locating any stockpiles, such as topsoil, away from the river
- using standard controls, such as silt curtains and other barriers to intercept surface runoff before it can enter the river
- maintaining equipment, including spill kits, to prevent fuel and oil leaks
- restricting vehicle activity in areas outside of the main construction zone
- ensuring that wash-water from concrete mixing, handling and cutting equipment is directed to areas away from the river
- stabilising and rehabilitating disturbed areas as soon as possible

- regular site inspections (including post-construction sign-off) particularly during and after rainfall and high-flow events
- monitoring water quality up and downstream of the site to ensure controls are effective.

The potential for groundwater drawdown to affect water levels in the Sabina River and how this will be managed is described in the next sub-section.

5.8 Groundwater

5.8.1 Key considerations

As detailed in Section 3 Existing Environment, the key environmental values and functions associated with groundwater within the area of influence of the Proposal are:

- local recharge to Sabina River (summer baseflow)
- interaction with local damplands and palusplain wetlands
- provide an important water resource to vegetation, such as *Melaleuca raphiophylla*, during the drying phase (summer/autumn).

5.8.2 Relevant activities

The Proposal includes the following activities with potential implications for groundwater:

- lowering of the superficial water table to below the base of mining as a result of dewatering
- disturbance of actual or potential ASS
- construction and operation of in pit and off path SEPs
- pit excavation, ore and reject handling and backfilling
- the use of hydrocarbons and chemicals
- landform reinstatement and rehabilitation.

5.8.3 Potential impacts

The following assessment of potential impacts to groundwater does not include those to surrounding users of the Yarragadee aquifer associated with the abstraction of water from that resource. The abstraction will continue within the volumes allocated and any other limitations set in the current groundwater licence held by Cable Sands (GWL 161841), which covers its entire operations in the south west.

Studies to predict the extent of groundwater drawdown for the Proposal have taken into account the current effects on the local water table by the Wonnerup mine (Attachment 5). The modelled cumulative results using the current mine plans from both projects (Figure 16) indicates a drawdown of between 10 and 30 cm that extends beneath the Sabina River, over a 150 m reach. The predicted duration of the cumulative drawdown footprint is one to three months. The URS groundwater model predicts full recovery of the superficial watertable within 6 months of the completion of mining, with no residual drawdown.

Whether this drawdown would significantly impact the seasonally groundwater-dependent pools within the Sabina River is difficult to confirm, owing to the predominantly clayey and low-yielding nature of the superficial formations (Attachment 2). The clays would be expected to reduce the rate of any downward leakage from the riverbed, but the aspect of reduced inflows, if any, would remain.

The nature of the interaction between the superficial water table and the damplands, wetlands and typical wetland plant taxa (*M. raphiophylla*) at Wonnerup South has not been studied to any great extent both because of the low-yielding nature and unsuitable quality of the aquifer, the lack of conservation values associated with the wetlands and that all occurrences of *M. raphiophylla* that are within the 10 cm groundwater drawdown contour actually fall within the development envelope and will be cleared

5.8.4 Proposed management

Cristal will prepare and implement a Dewatering Operating Strategy (as required by DoW) that will include the following approaches and measures to protect the beneficial uses of the local superficial water resource from the mining proposal:

- incorporating a 100 m standoff from the Sabina River, as marked from the edge of the river reserve (Figure 9) for all activities apart from the bridge/service corridor
- restricting dewatering to the safest minimum depth for dry mining
- promoting rapid recharge by backfilling with sand tails as soon as possible, particularly in proximity to the Sabina
- monitoring groundwater levels using the existing network of piezometers
- developing response triggers for groundwater drawdown near the Sabina River
- implementing recharge/infiltration cells adjacent to the river, if trigger values are exceeded

The Dewatering Operating Strategy will be prepared and implemented to the satisfaction of the DoW, in accordance with its licensing provisions.

Other management controls associated with the groundwater environment are contained within the Rehabilitation and Closure section of this proposal.

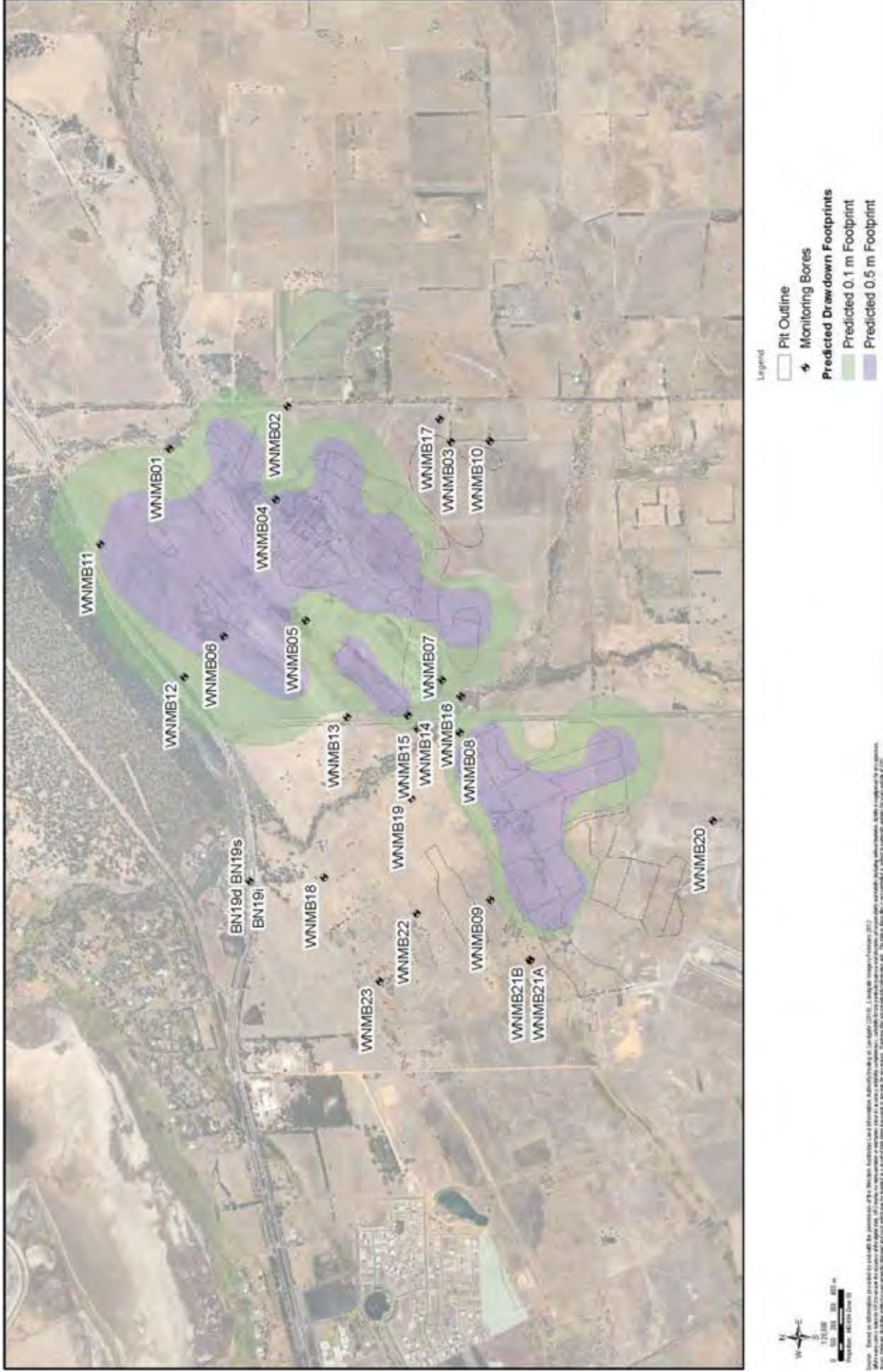


Figure 16: Predicted maximum drawdown distribution (URS 2013)

5.9 Acid sulfate soils

5.9.1 Key considerations

As described in Section 3 Existing Environment, the key environmental values and functions associated with acid sulfate soils (ASS) at the Proposal site are:

- the acid sulfate soil risk is less than that at the existing Wonnerup mine, and below DER criteria for pro-active management
- the existing groundwater chemistry is unsuitable for domestic purposes or for stock watering and low-pH soils already occur on the site
- the superficial aquifer discharges into the nearby Sabina River, which itself flows into the Ramsar-listed Vasse Wonnerup wetland system, 2 km downstream.

5.9.2 Relevant activities

The Proposal includes the following activities with potential implications for ASS:

- soil removal (and stockpiling) during construction from areas to be mined and adjacent sites where supporting infrastructure will be located
- construction and operation of project infrastructure and facilities where excavation is required (including the Sabina River crossing)
- lowering of the superficial water table to below the base of mining
- pit excavation, ore and reject handling and backfilling
- stormwater and process water collection and management
- landform reinstatement, contouring and rehabilitation.

As described in Section 4 Proposal Description, all surface and groundwater from within the development area will be intercepted before being pumped to the existing Wonnerup mine for treatment and re-use or discharge if surplus to requirements.

5.9.3 Potential impacts

The preliminary screening assessment (Attachment 2) indicated that a very low proportion of soils from the boreholes sampled contain sulfide minerals which could generate acidic conditions upon oxidation. However, an ASS monitoring strategy is required, in keeping with the DEC (2012) guidance framework. This would also apply to the construction of the Sabina River crossing.

5.9.4 Proposed management

Cristal has prepared an Acid Sulfate Soils Management Plan (Attachment 2) that includes the following approaches and measures to monitor and, if necessary, respond to the acid sulfate soils risk:

- monitoring groundwater chemistry using the existing network of piezometers
- monitoring the pH and chemistry of the pit sumps and combined water circuit
- developing response triggers for groundwater, sump water and process water chemical indicators
- implementing the following responses if triggered:
 - treat dewatering sumps/pipelines with lime
 - activate or increase the in-line lime dosing component of the process water treatment system
 - halting discharge of overflow from the process water dam (excess water can also be stored in SEPs).

Note that some of these controls may become specific requirements of the site environmental licence required from DER in order to commence operations. Other management controls

associated with the soil and groundwater chemistry following mining are contained within the Rehabilitation and Closure section of this proposal.

5.10 Noise and vibration

5.10.1 Key considerations

As described in Section 3 Existing Environment, the key environmental aspects associated with noise from the Proposal are:

- there are 38 residences within 1 km of the tenement boundary, however, apart from the two dwellings on the Proposal site, there are no residences within 1 km of the boundary of the Proposed development area (which will be demarcated by noise bunds).
- there is already a high level of noise associated with Bussell Highway and the regional airport, but these influences diminish between about 11:00 p.m. and 4:00 a.m.

5.10.2 Relevant activities

As described in Section 4 Proposal Description, the Proposal will follow three distinct phases:

- a site development phase, where there is broad-scale removal of topsoil and relocation of ore from the northern satellite for the construction of sight and noise bunds – earth-moving activities by heavy vehicle during this period will be restricted to 7:00 am to 7:00 pm, Monday to Saturday
- a site operations phase, where activities are more focused at the pit and involves a lower level of mobile machinery, but an increase in pumps and screens
- a closure phase, where once topsoil stockpiles have been replaced over the reconstructed soil profile, there is very little requirement for heavy machinery to operate on the site – activities at Wonnerup would be expected to return to full scale at this point.

5.10.3 Potential impacts

The impacts of the first two phases of operations in ambient noise levels are currently being modelled by SVT Engineering Consultants, which modelled the Wonnerup mine and assisted in the refinement of the mine plan to ensure compliance with the *Environmental Protection (Noise) Regulations 1997*. The modelling and refinement of the Wonnerup South mine plan is expected to be completed in the near future, and will be referred to the DER as part of an application for a Works Approval.

5.10.4 Proposed management

Cristal will prepare and implement noise management plans for both the construction and operation phases of the Proposal. The two plans will address the different risk profiles that will exist for the different phases. Both plans will be prepared in consultation with the DER, and will include the use of continuous noise loggers that provide real-time neighbourhood noise levels to the minesite.

5.11 Visual amenity and light

5.11.1 Key considerations

As described in Section 3 Existing Environment, the key environmental aspects associated with visual amenity for the Proposal are:

- relative proximity to regional roads
- proximity to the Busselton Regional Airport (BRA).

5.11.2 Relevant activities

The Proposal includes the following activities with potential implications for visual amenity and light:

- relatively large-scale soil disturbance and earthworks (visual)
- night-time operations and inspections (lighting).

5.11.3 Potential impacts

The potential for visual impacts to be observed from the Bussell Highway is considered to be low, largely by virtue of distance, as the edge of the mine is 1 km from the highway. There is also considerable screening by vegetation along Bussell Highway and also the Sabina River (Figure 2). The mine is substantially closer to Sues Road, running alongside it for about a kilometre. Over a short section of the road (about 300 m), mining will be visible on both sides of Sues Road. This latter aspect will be important when planning the placement of lighting to support safe night-time operations on both sites.

The Proposal also comes close to the BRA, however the airport currently restricts operations to daylight hours (with exceptions) and the influence of lighting on aircraft is expected to be minimal and easily managed.

5.11.4 Proposed management

The following management and mitigation measures will be implemented to manage visual amenity and light spill:

- topsoil stockpiles will be placed along the northern and eastern boundaries of the operations and will be treated to encourage vegetation (pasture species) growth and will obscure views of mine infrastructure
- lighting will be installed as per Australian Standard 4282 *Control of obtrusive effects of outdoor lighting*
- regular consultation will be conducted with the BRA and the City of Busselton regarding the impact of minesite lighting.

If required, lighting will be adjusted or moved to minimise light spill and related amenity issues.

5.12 Dust emissions

5.12.1 Key considerations

As described in Section 3 Existing Environment, the key environmental aspects associated with dust emissions for the Proposal are:

- relative proximity to regional roads
- seasonally wet conditions
- good distance to nearest neighbours (over 1 km away and on the other side of Bussell Highway).

5.12.2 Relevant activities

The Proposal includes the following activities with the potential to generate excessive dust emissions:

- vegetation and topsoil removal
- construction of roadways and infrastructure areas
- general operation of heavy equipment
- routine earthmoving activities.

The absence of overburden is expected to have some benefit owing to the related reduction in earthworks and stockpiles.

5.12.3 Potential impacts

Mining activities involve the disturbance of large quantities of soil and earthen material, often over a wide area and in exposed locations. Such activities generate dust that, if not adequately controlled, can cause nuisance and aesthetic impacts for adjoining landowners or pose safety risks for road users. Site development and construction activities prior to mining can also generate substantial amounts of dust.

Excavation of the ore itself does not generate much dust, as the ore material is quite sandy and coarse (~50 µm), with good levels of soil moisture and low clay content. In-pit operations also tend to generate less dust than surrounding activities due to the reduced airflow within the pit. Mineral separation is a wet process and therefore does not generate appreciable dust.

Removal and replacement of topsoil material has a higher risk of dust generation due to the large volumes of material involved and generally lower levels of soil moisture, particularly during summer earthworks campaigns.

In addition to dust, the use of earthmoving machinery, other equipment and site vehicles will cause minor exhaust emissions. Such emissions are not expected to result in amenity or other impacts on adjoining landowners.

5.12.4 Proposed management

Cristal will apply its standard dust management and monitoring procedures as part of its general Environmental Management Plan (EMP). The procedures will include the following approaches and measures to minimise the emission of dust from the Proposal:

- training and awareness programs
- regular inspections
- minesite speed limits
- topsoil will normally only be stripped outside summer months (i.e. not between December to February) – exceptions may be in locations where site access is not possible in wet conditions, such as swamp or clayey areas
- water carts will be used to suppress dust when conditions require it
- topsoil will be stripped on a progressive basis so the disturbed area is the minimum required for continued operation
- weather conditions will be assessed before commencing topsoil stripping, and reassessed on a daily basis during stripping
- at the completion of stockpiles an appropriate soil stabilisation treatment will be applied (eg mulch or seeding)
- chemical stabilisation in areas of moderate traffic use (e.g. Dustex)
- application of sprayed fines to stabilise cleared areas and stockpiles not subject to traffic
- monitoring dust emissions along the premises boundary using a combination of gravimetric (e.g. Hi-vol) and photometric (e.g. Dustrak) methods.

The management of dust is expected to be a condition of operation, as specified in the DER environmental licence.

5.13 Hydrocarbon/chemical use

5.13.1 Relevant activities

The Proposal includes the following activities requiring hydrocarbon or chemical use:

- operation, refuelling and light maintenance of earthmoving machinery
- chemical stabilisation of road surfaces (as required).

Note that major repairs to heavy equipment will largely be conducted off-site, either at the contractor's workshop or at facilities at Wonnerup.

Although treatment at the Wonnerup water treatment plant of any water recovered from the Proposal will involve the use of flocculants and coagulants (as approved by DSEWPAC), it is not considered in this assessment on the basis that the Wonnerup South proposal does not represent a change in use at the Wonnerup site.

5.13.2 Potential impacts

This assessment predominantly refers to hydrocarbons, as the mobile refuelling and light repairs to earthmoving equipment are the major activity in this regard. Light stands and pumps are typically electric and do not require refuelling.

5.13.3 Proposed management

Cristal maintains a register of those chemicals classified as hazardous, which indicates the name of the chemical, maximum quantity and location of the chemical as well as relevant material safety data sheets (MSDS).

The volumes of hydrocarbons and dangerous goods stored on site will be below manifest quantities and stored according to the Western Australian *Code of Practice for the Storage and Handling of Dangerous Goods*.

In addition, the following management and mitigation measures will be implemented to manage risks associated with hydrocarbon and chemical use:

- the storage, use and disposal of bulk hazardous materials will be as per the Dangerous Goods Regulations and Permits
- management of hydrocarbons and chemicals will focus on correct storage, handling and disposal techniques
- mobile refuelling of equipment and vehicles will be undertaken following set procedures to acceptably minimise the risk of spills and to ensure adequate containment and bunding is in place to contain any spills that may occur
- spill kits containing appropriate equipment for control, containing and cleanup hydrocarbon and chemical spills will be made available in appropriate locations and maintained
- the use and disposal of any chemicals required on site will be managed through *WI269 Hazardous and Dangerous Chemical Approval and Disposal*
- the use and disposal of hydrocarbons will be managed through *WI062 Drainage of Hydrocarbon Bunds and Sumps of Stormwater*
- an Emergency Response Plan will be developed for the Proposal, building on to the existing plan for the Wonnerup mine and will outline the procedures for control and management of hydrocarbon spills, chemical spills and risks associated with dangerous goods.

The proposed management of the storage, use and disposal of hydrocarbons and chemicals, is expected to acceptably minimise the risk of environmental impacts from hydrocarbon or chemical spills.

5.14 Radiation

5.14.1 Key considerations

Mineral sands contain trace amounts of uranium and thorium, which reflects the nature of the original source rock. In many areas, such as at Wonnerup South and southwest beaches, mineral sands have been deposited close to or on top of the ground surface and represent a natural low level source of radiation.

5.14.2 Relevant activities

The Proposal includes the following activities that may affect radiation levels on the site:

- removal of topsoil and subsequent uncovering of ore that may contain trace amounts of radioactive materials
- the burial of reject tailings from the North Shore MSP.

5.14.3 Potential impacts

The extraction and separation of HMC, with regards to screening and tailings return, does not act to concentrate normally-occurring radioactive materials in any one area of the mine path.

5.14.4 Proposed management

The keeping and use of radioactive substances in Western Australia is governed by the *Radiation Safety Act 1975* (RS Act) and the *Radiation Safety (General) Regulations 1983* (RS Regulations), which are administered by the Radiological Council, a statutory body set up under the RS Act.

Radiation safety in mine sites is also subject to the *Mines Safety and Inspection Act 1994* (MSI Act) and the *Mines Safety and Inspection Regulations 1995* (MSI Regulations). The MSI Act and MSI Regulations are administered by the State Mining Engineer (SME).

The Mineral Sands industry is deemed to fall under the provisions of Part 16 of the MSI Regulations and is thus required to have in place an approved Radiation Management Plan and a Radiation Safety Officer (mining and milling). Under the plan, pre-disturbance and post-mining radiation surveys are conducted to ensure that levels are as low as reasonably achievable and comply with the radiation safety standards.

5.15 Waste management

There will be no temporary or permanent disposal of solid waste to land at the site. All solid wastes will be directed through the Wonnerup site for collection by appropriately licensed carriers for disposal or recycling. Similarly, all liquid wastes, with the exception of wastewater from the ablution facilities, will be removed from site by a licensed carrier. Depending on the type that will be used, wastewater from the workforce ablution facilities will either be disposed through an appropriately designed and constructed septic system in accordance with the requirements of the *Health Act 1911*, or collected and disposed of off-site at an appropriate receiving point.

6 Social impacts and management

6.1 Aboriginal heritage

6.1.1 Key considerations

As described in Section 3 Existing Environment, the key heritage values associated with the Proposal are:

- Site ID 17353 Sabina River, which has significant mythological and historical values
- Site ID 17350 Sabina River Camp Ground, which is considered not to be separate to the Sabina River site.

The historical association with the river increases the potential for aboriginal artefacts or remains to be encountered during mine development, however archaeological surveys of the site have not recorded any significant finds.

6.1.2 Relevant activities

The construction of the service corridor across the Sabina River will necessarily disturb the Registered site Sabina River. The nature of the design and construction activities is described in section 3.10.

Earthworks associated with the mine may also uncover aboriginal artefacts or remains.

6.1.3 Proposed management

Cristal has commissioned a Heritage Consultant (Ethnoscience) to prepare and submit an application under s18 of the Aboriginal Heritage Act. Included in the application is the formal commitment not to conduct any further development activities (i.e. in addition to the service crossing and corridor) within 100 m of the Sabina River.

In order to ensure compliance with the Aboriginal Heritage Act and the recommendations arising from the ethnographic consultation undertaken on behalf of Cristal, Aboriginal observers from the Nyungar Community will be invited to be present during the initial site works to monitor for archaeological materials.

In addition, work will be conducted in accordance with Cristal's Standard Procedures, which include training and awareness programs and necessary actions to be taken if suspected heritage material is discovered, including the immediate cessation of all further ground-disturbing activities in that area.

7 Rehabilitation and closure

7.1 Mine Closure Plan

The Wonnerup South Mine Closure Plan has been prepared in accordance with the ANZMEC/MCA Strategic Framework for Mine Closure (ANZMEC/MCA 2000) and refers to methodology outlined in the DMP/EPA Guidelines for Preparing Mine Closure Plans (DMP /EPA 2011) and Leading Practice Sustainable Development in Mining handbooks and the Planning for Integrated Mine Closure Toolkit (ICMM 2008).

Consistent with its environmental policy, Cristal will seek to decommission and rehabilitate the Proposal site in a sustainable manner and leave a site that is safe, stable and non-polluting, consistent with agreed post mining outcomes and land uses and without unacceptable liability to the State of Western Australia.

The Closure Plan identifies that the key activities of mine closure will include:

- pre-closure planning
- determine final landuse
- develop closure objectives and completion criteria
- stakeholder consultation
- collection and analysis of closure data
- closure execution
- decommissioning
- remediation
- rehabilitation earthworks
- revegetation
- post-closure monitoring and maintenance.

The Closure Plan also addresses:

- progressive rehabilitation, where possible, during operations
- accountability for plan implementation
- resources needed to assure conformance with the plan
- financial provisioning for closure.

The Closure Plan will be regularly revised and updated as the mine plan progresses.

7.2 Timeline

A conceptual timeline for rehabilitation and closure activities is presented in Table 10.

Table 10: Conceptual timeline (dependent on environmental assessment outcomes)

Activities	2016				2017				2018				2019				2020				2021				2022			2023			2028
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q1	Q2	Q3	Q3
Site development	■	■	■	■																											
Mining & production					■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■							
Final landform																															
Decommissioning																															
Replanting/ reseeded																															
Monitoring and maintenance																															
Pasture rehabilitation completed																															
Native rehabilitation assessment																															

7.3 Final land use and closure concepts

7.3.1 Closure objectives

The key objectives of the Wonnerup South Mine Closure Plan are:

- to protect the environment and public health and safety by using safe and responsible closure practices
- to establish conditions that are consistent with the end land use objectives, as agreed with the landowner and relevant authorities
- to reduce or eliminate environmental effects once the mine operations cease
- to reduce the need for long-term monitoring and maintenance by establishing effective physical and chemical stability of disturbed areas.

7.3.2 Final landuse

The final landuse for the Proposal site will be a return to productive grazing land and with an equivalent amount of native vegetation as existed prior to mining. The precise details of the post-mining landscape, such as consolidation of the rehabilitation areas, will be finalised prior to the commencement of ground-disturbing activities.

7.3.3 Closure concepts

Areas that are disturbed by mining will be returned to annual pasture of comparable productivity to the pre-mining condition. Soil profile conditions and subsequent pasture productivity may vary across the property depending on whether disturbed areas have been mined. Consequently, mine pit and infrastructure areas are defined as different domains/management areas.

Domain - Infrastructure area

Infrastructure areas will have been used for a combination of activities including stockpiling ore, stockpiling topsoil, access roads or off path SEPs. Under most infrastructure sites such as the ore stockpiles and off path SEPs, topsoil will have been stripped and stockpiled and will be returned as part of rehabilitation. Under other sites the underlying soil profile will remain unchanged, although surface ripping may be required to alleviate compaction.

Domain - Mine pit area

Mined and will require soil profile reconstruction. Rehabilitation works will be carried out progressively as mining progresses through the pits. The mined area will be progressively backfilled with sand and clay tails and revegetated to the pre-mining land use.

7.3.4 Completion criteria

Completion criteria for agricultural land will be developed with the landowner as part of the post-mining landscape plan. As a broad objective, primary productivity of the rehabilitated site is to be comparable to that which existed prior to mining. Pasture productivity will be assessed by an independent agronomist prior to disturbance and then for two seasons following rehabilitation. Some areas, which previously consisted of a deep sandy profile, may have an improved capacity to support pasture growth after mining.

Completion criteria for native vegetation offset planting will be developed in consultation with the relevant government agencies as part of obtaining all of the necessary approvals for the Proposal, including the native vegetation clearing permit (see Section 7.4.5).

7.4 Decommissioning and rehabilitation activities

7.4.1 Infrastructure removal and reinstatement

All mine infrastructure, pipes and services will be removed. The retention of Sabina River crossing and any other infrastructure will be as per landowner agreements (including the potential airport expansion).

All fences, gates and watering points removed by Cristal will be replaced in their original positions (or relocated as nominated by the landowner) with fences of a style and type similar to the fences that have been removed.

7.4.2 Backfilling and landforming

Areas that were excavated during mining will have been backfilled with the sand tailings, clay fines and reject (oversize) materials generated from the mined ore during the concentration process. As these waste products have been physically separated and are not chemically altered, they are suitable to be reincorporated back into the reconstructed soil profile.

7.4.3 Soil emplacement

The new surface profile will be ripped and then the topsoil will be re-spread to complete the reconstruction process.

To help ensure that soil reconstruction strategies produce a soil profile that will support productive pastures, Cristal will undertake a post-mining study of reconstructed soils at the Proposal site. Test pits will be established across the re-worked landform to ensure sufficient mixing of materials (fines and tailings). Examination will confirm there are no clay layers evident that are likely to inhibit root development within the plant growth zone of pasture rehabilitation areas.

Groundwater monitoring will continue until it can be reasonably demonstrated that the rehabilitated soils are hydrologically and chemically stable.

7.4.4 Pasture establishment

The disturbed agricultural areas will be restored to pasture and maintained for two growing seasons following sowing, including reapplication of fertiliser prior to start of the second growing season. The disturbed areas will be seeded with a pasture seed mix determined in consultation with an agronomist and the landowner, except where native vegetation is to be established (see Section 7.4.5).

Annual performance monitoring and maintenance, including controlled grazing of pasture areas and spot spraying of weeds, as agreed with the landowner, will be undertaken during the post-closure period. Pasture assessment will occur on a biannual basis and include visual assessment of botanical composition confirmed by hand sorting. Written reports will be provided to the landowner following each assessment and the results summarised in the company's annual environmental report.

After this time the property will be returned to the landholder, subject to agreed pasture composition and production being achieved.

7.4.5 Native vegetation establishment and offsets

Native vegetation corresponding to the same areal extent that was cleared will be re-established on-site using native vegetation seed mix at the site and/or will be offset by upgrading and managing remnant vegetation in offset locations.

On-site native vegetation may be established in one or more consolidated areas, rather than in the original scattered remnant locations, depending upon the outcomes of discussions with the landholder, DER and DSEWPAC.

Offset planting and management of native vegetation will be developed in consultation with DSEWPAC, DMP and DER as part of project approvals for the Proposal and will be outlined in an Offsets Management Plan.

The management of the native vegetation offsets (and on-site native revegetation) is expected to be comparable to that already agreed for the Wonnerup mine. Monitoring of rehabilitation will use a series of plant biodiversity parameters including species richness and diversity, plant density and percentage cover as indicators of ecosystem development and stability, which is endorsed by the EPA (EPA 2006). Monitoring will be annual for the first two years, with subsequent monitoring at five and ten years after rehabilitation, in line with the final completion criteria.

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